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PRODUCTION OF ATMOSPHERIC NITROGEN

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HEARING

BEFORE THE

COMMITTEE ON AGRICULTURE AND FORESTRY
UNITED STATES SENATE

SIXTY-SIXTH CONGRESS
SECOND SESSION

ON

S. 3390

A BILL TO PROVIDE FURTHER FOR THE NATIONAL DEFENSE; TO ESTABLISH A SELF-SUSTAINING FEDERAL AGENCY FOR THE MANUFACTURE, PRODUCTION, AND DEVELOPMENT OF THE PRODUCTS OF ATMOSPHERIC NITROGEN FOR MILITARY, EXPERIMENTAL, AND OTHER PURPOSES; TO PROVIDE RESEARCH LABORATORIES AND EXPERIMENTAL PLANTS FOR THE DEVELOPMENT OF FIXED-NITROGEN PRODUCTION; AND FOR OTHER PURPOSES

Printed for the use of the Committee on Agriculture and Forestry

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

COMMITTEE ON AGRICULTURE AND FORESTRY.

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PRODUCTION OF ATMOSPHERIC NITROGEN.

MONDAY, MARCH 22, 1920.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met pursuant to call of the chairman in room 326, Senate Office Building, at 10 o'clock a. m., Senator Asle J. Gronna presiding.

Present: Senators Gronna, Norris, Kenyon, Wadsworth, McNary, Capper, Gore, Smith of South Carolina, and Kendrick.

Present also: Senator Oscar Underwood, of Albama; Representative E. B. Almon, of Alabama; Hon. Newton D. Baker, Secretary of War; Maj. Gen. Clarence Williams, Chief of Ordnance, War Department; Col. J. H. Burns, and Mr. G. J. Roberts.

The committee thereupon proceeded to the consideration of S. 3390, which is here printed in full, as follows:

[S. 3390, Sixty-sixth Congress, first session.]

A BILL To provide further for the national defense; to establish a self-sustaining Federal agency for the manufacture, production, and development of the products of atmospheric nitrogen for military, experimental, and other purposes; to provide research laboratories and experimental plants for the development of fixed-nitrogen production; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized and empowered to designate any five persons to act as an organization committee for the purpose of organizing a corporation under authority of and for the purposes enumerated in this act.

ORGANIZATION.

The persons so designated shall, under their seals, make an organization certificate, which shall specifically state the name of the corporation to be organized, the place in which its principal office is to be located, the amount of capital stock, and the number of shares into which the same is divided, and the fact that the certificate is made to enable the corporation formed to avail itself of the advantages of this act. The name of such corporation shall be United States Fixed-Nitrogen Corporation.

The said organization certificate shall be acknowledged before a judge of some court of record or notary public, and shall be, together with acknowledgment thereof, authenticated by the seal of such notary or court, transmitted to the Secretary of War, who shall file, record, and carefully preserve the same in his office. Upon the filing of such certificate with the Secretary of War as aforesaid, the said corporation shall become a body corporate and as such, and in the name United States Fixed-Nitrogen Corporation, shall have power—

First, to adopt and use a corporate seal;

Second, to have succession for a period of twenty years from its organization, unless it is sooner dissolved by an act of Congress, or unless its franchise becomes forfeited by some violation of law;

Third, to make contracts;

Fourth, to sue and be sued, complain, and defend in any court of law or equity;

Fifth, to appoint by its board of directors such officers and employees as are not otherwise provided for in this act; to define their duties, to fix their salaries, in its discretion to require bonds of any of them, and to fix the penalty thereof, and to dismiss at pleasure any of such officers or employees;

Sixth, to prescribe by its board of directors by-laws not inconsistent with law regulating the manner in which its general business may be conducted and the privileges granted to it by law may be exercised and enjoyed;

Seventh, to exercise by its board of directors or duly authorized officers or agents all powers specifically granted by the provisions of this act and such incidental powers as shall be necessary to carry on the business for which it is incorporated within the limitations prescribed by this act, but such corporation shall transact no business except such as is incidental and necessarily preliminary to its organization until it has been authorized by the Secretary of War to commence business under the provisions of this act.

The corporation shall be conducted under the supervision and control of a board of directors, consisting of not less than three nor more than eleven members, to be appointed by the Secretary of War. The directors so appointed shall hold office at the pleasure of the Secretary of War. The Secretary of War shall be ex-officio chairman of the board and shall have power to designate one of the directors as vice chairman. The vice chairman shall perform the duties of chairman in the absence of the Secretary of War.

The board of directors shall perform the duties usually appertaining to the office of directors of private corporations and such other duties as are prescribed by law.

POWERS OF THE CORPORATION.

The corporation shall have power—

(*a*) To purchase, acquire, operate, and develop in the manner prescribed by this act and subject to the limitations and restrictions thereof the following properties owned by the United States:

1. United States nitrate fixation plants numbered one and two, located, respectively, at Sheffield, Alabama, and Muscle Shoals, Alabama, together with (*a*) all real estate used in connection therewith; (*b*) all tools, machinery, equipment, accessories, and materials thereunto belonging; (*c*) all laboratories and plants used as auxiliaries thereto, including the fixed nitrogen research laboratory at Washington, the Waco limestone quarry in Alabama, the electric power unit at the Warrior River station of the Alabama Power Company, and transmission lines, and many others used as auxiliaries of United States fixed nitrogen plants numbered one and two.

2. Any other plants or parts of plant, equipment, accessories, or other properties belonging to the United States, which are under the direct control of the President or of the War Department, and which the President or the Secretary of War may deem it advisable to transfer, convey, or deliver to said corporation for use in connection with any of the purposes of this act, or for any purpose incidental thereto.

(*b*) To acquire, establish, maintain, and operate such other laboratories and experimental plants as may be deemed necessary or advisable to assist it in furnishing to the United States Government and others, at all times, nitrogen products for military or other purposes in the most economical manner and of the highest standard of efficiency.

(*c*) To sell to the United States such nitrogen products as may be manufactured by said corporation for military or other purposes.

(*d*) To sell any or all of its products not required by the United States to producers or users of fertilizers or to others.

(*e*) By direction of the President, to act as his agent in carrying out and performing any or all of the duties imposed upon him by section 124 of the act of June 3, 1916, known as the national defense act, including, after its completion, the operation of the hydroelectric power plant now being constructed at Muscle Shoals, and the use and sale of the hydroelectric power to be developed under authority of the act of June 3, 1916, aforesaid, and the President is authorized, in his discretion, to delegate to the corporation any and all powers and duties conferred or imposed upon him by said act which relate to the production, development, or manufacture of atmospheric nitrogen products, or which are incidental thereto, and to pay into the Treasury of said company any unexpended balance out of the appropriation made by section 124 of the act of June 3, 1916, such funds to be used by the corporation for the purpose of said act as amended by this act.

(*f*) To enter into such agreements and reciprocal relations with others as may be deemed necessary or desirable to facilitate the production and sale of nitrogen products on the most scientific and economical basis.

(*g*) To purchase, lease, or otherwise acquire United States or foreign patents and processes or the right to use such patents and processes.

(*h*) To obtain from the United States or from foreign governments patents for discoveries or inventions of its officers and employees, and, in the discretion of its board of directors, to require any and all of its officers and employees as a condition of their employment to enter into agreements with the company that the patents for all such discoveries or inventions shall be and become in whole or in part the property of the corporation.

(*i*) To assume any or all obligations of the United States entered into in connection with the construction, maintenance, and operation of the plants to be transferred to the corporation under the provisions of this act.

(*j*) To deposit its funds in any Federal reserve bank or with any member bank of the Federal reserve system.

(*k*) To sell and export any of its surplus products not purchased by the United States or by persons, firms, or corporations within the United States.

(*l*) To invest any surplus of available funds not immediately used for the operation construction, or maintenance of its plants or properties in United States bonds or other securities issued by the United States.

(*m*) To lease or purchase such buildings or properties as may be deemed necessary or advisable for the administration of the affairs of the corporation or for carrying out the purposes of this act; and with the approval of the Secretary of War to lease to other persons, firms, or corporations any of its properties not used or needed by the corporation, or to enter into agreements with others for the operation of such properties. In the operation, maintenance, and development of the plants purchased or acquired under this act the corporation shall be free from the limitations or restrictions imposed by the act of June 3, 1916, and shall be subject only to the limitations and restrictions of this act.

CAPITAL STOCK.

The capital stock of the corporation shall be divided into two classes, to be known as common and preferred. The common stock shall be without par value. The company shall have no power to issue stock except that issued to the United States under authority of this act.

In exchange for the properties purchased or acquired from the United States and from time to time transferred, conveyed, or delivered to the corporation by the President or by the Secretary of War, as provided by this act, the corporation shall cause to be executed and delivered to the Secretary of War a certificate for all of the common stock of the corporation, which certificate shall be evidence of the ownership of the United States of all such common stock. In consideration of the issuance of such common stock to the Secretary of War, the President and the Secretary of War are authorized and empowered to transfer, convey, and deliver to the corporation all of the real estate, buildings, tools, equipment, supplies, and other properties belonging to, used by or appertaining to the plants and properties to be acquired by the corporation under the terms of this act, and to transfer, convey, and deliver as and when they may deem it advisable any other equipment, accessories, plants, or parts of plants or other property referred to in this act and which the corporation is authorized to acquire or purchase from the United States under its provisions.

The President or the Secretary of War, as a condition of the transfer, conveyance, or delivery to the corporation of any property herein referred to, may require the corporation to assume any and all agreements and obligations entered into by the United States in connection with the construction, maintenance, or operation of such plants or other property.

The corporation shall have the power to issue and sell preferred stock in any amount not to exceed $12,500,000, of a par value of $100 per share, such stock to be entitled to 5 per centum dividends. All such stock shall be subscribed by the United States of America, and such subscription shall be subject to call upon the vote of the board of directors of the corporation with the approval of the Secretary of War at such time or times as may be deemed advisable, and there is hereby appropriated out of any money in the Treasury not otherwise appropriated the sum of $12,500,000, or so much thereof as may be necessary, for the purpose of making payment upon such subscription when and as called.

Receipts or certificates for payment by the United States of America for or on account of such stock shall be issued by the corporation to the Secretary of War and shall be evidence of the stock ownership of the United States. The Secretary of War is authorized to use any funds now available for the completion of the construction and equipment of such United States nitrate plants, numbers one and two, and accessories, either after or before the conveyance and delivery of such properties to the corporation in accordance with the terms of this act.

DISTRIBUTION OF EARNINGS.

All net earnings of the corporation not required for its organization, operation, and development shall be used—

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(*a*) To pay dividends on outstanding preferred stock, such dividends to be paid into the Treasury of the United States as miscellaneous receipts;

(*b*) To develop and improve its plants and equipment;

(*c*) To create a reserve or surplus fund until such fund amounts to $2,500,000;

(*d*) The remainder to be paid into the Treasury of the United States as miscellaneous receipts.

MISCELLANEOUS.

The Federal reserve banks shall be authorized to receive deposits of the corporation. The corporation shall not have power to mortgage or pledge its assets, or to issue bonds secured by any of its properties.

The United States shall not be liable beyond its stock subscription for any debts, obligations, or other liabilities of the corporation.

The corporation and all of its assets shall be deemed and held to be instrumentalities of the United States and as such they and the income derived therefrom shall be exempt from Federal, State, and local taxation. The directors, officers, attorneys, experts, assistants, clerks, agents, and other employees of the corporation shall not be officers or employees of the United States within the meaning of any statutes of the United States, and the property and moneys belonging to said corporation, acquired from the United States, or from others, shall not be deemed to be the property and moneys of the United States, within the meaning of any statutes of the United States.

The accounts of the corporation shall be audited under the regulations to be prescribed by the Secretary of War, who shall include in his annual report to Congress a detailed statement of the fiscal operations of said corporation.

The Secretary of War may appoint any officer of the War Department or any other person as a director of the corporation, and under regulations to be prescribed by the Secretary of War any officer of the War Department may serve as an officer or employee of the corporation, and may receive such compensation for services rendered to the corporation as the board of directors, with the approval of the Secretary of War, may prescribe.

If any clause, sentence, paragraph, or part of this act shall for any reason be adjudged by any court of competent jurisdiction to be invalid, such judgment shall be confined in its operation to the clause, sentence, paragraph or part thereof directly involved in the controversy in which such judgment shall have been rendered.

The right to amend, alter, or repeal this act is hereby expressly reserved.

The CHAIRMAN. We have met this morning to hear the Secretary of War and his assistants on Senate bill 3390, introduced by Senator Wadsworth and referred to this committee for consideration.

Mr. Secretary, if you will be good enough to proceed and make your statement in your own way in reference to this bill, the committee will be glad to hear you.

STATEMENT OF HON. NEWTON D. BAKER, SECRETARY OF WAR.

Secretary BAKER. I shall dwell only in the most general way, Senator, with this project, for the reason that it is an expert problem, and the experts are here, and the committee will get very much more information by listening to their accurate and scientific statements than they can get from any generalizations by me.

I want, however, to open the hearing, if I may, by a statement which will show the committee the importance of the project under consideration. During the war we spent approximately $85,000,000 in building two nitrate plants at Muscle Shoals. Plant No. 1, the smaller of the two, is known as the Haber Process Plant; and the larger of the two, or No. 2 Plant, upon which something over $70,000,000 has been spent, is known as the Cyanamid Process Plant.

At a later stage in the hearing, the committee will be given detailed information as to these processes and all other processes for the synthetic fixation of nitrogen, but the aggregate of the two plants involves expenditures by the Government, as I stated, of substantially $85,000,000.

This committee, I assume, is not interested in the question of the justification which the Government had for making these expenditures, but it is interested in the question of the future of the plants.

Three possible courses are open to the Government: One is to scrap and salvage these plants. As all of the machinery is of a very highly specialized character, and the major part of the investment is in buildings and in such specialized machinery, the salvage value of the plants is exceedingly small as compared with the outlay.

The CHAIRMAN. If you will pardon me, Mr. Secretary, I take it that one of the moot questions is really whether the Government of the United States shall carry on this work, take over the plants and manufacture this nitrogen for the purpose of carrying on the business and selling the product to consumers. I assume that that will be one of the debatable questions. I think I may say—and Senator Underwood will doubtless bear me out in the statement—that it was stated at the time that we appropriated this money that there was no objection from any source whatever to the expenditure of any amount of money for the purpose of manufacturing nitrogen for the purpose of carrying on the war. But, of course, the question of operating a nitrogen plant for the purpose of selling fertilizers to the farmer is somewhat of a change from our present policy, and I think perhaps that would be the question for our present consideration.

Secretary BAKER. That will be an important question.

Senator UNDERWOOD. If you will allow me—I am not on the committee, but I would like to make this statement: You will recall, Mr. Chairman, that the original bill on which this is all based came from this committee and passed the Senate, and provided for the development of this industry, primarily, for making nitrogen for the protection of the Government in making powder. But, secondarily, the bill itself contemplated that the product should be used for the manufacture of fertilizer also.

Senator SMITH of South Carolina. I, as you remember, was the author of the bill, and the purpose of the bill was that, since war was imminent, that we would construct plants of sufficient size to furnish all of the nitrogen the Government might need during the time of war, and that then during times of peace whatever surplus there was over the needs of the Army should be used for agricultural purposes.

The CHAIRMAN. I did not raise the question with intent to interfere with the Secretary's statement, but simply to bring forth his views with reference to the question.

Secretary BAKER. I realize that.

The CHAIRMAN. The committee will have to thrash that out later on, of course.

Secretary BAKER. If I may continue as I was going, there are three possibilities: One is the dissembling and salvaging of the plants, and because of the loss involved that is quite out of the question. The second is to put the plants in stand-by condition, paint its corrodible parts and let it stand there idle and do nothing with the plant until another emergency arose, if any does arise, and keep as an emergency reliance of the Government. That, of course, is a tremendously expensive thing to do, because we would get no interest at all upon the $85,000,000 invested, and it is not unlikely that by the time another emergency would arise which would require us to resort to plants using processes developed in the future by other people and so changed as to make those we have an obsolete or obsolescent reliance.

Senator **Gore**. Mr. Secretary, would that be an argument in favor of not operating the plant? That is like pursuing a mirage. There is always a possibility of a new method being discovered and succeeding an old method.

Secretary **Baker**. Senator, if I were proposing simply to complete this plant, I think your proposal would be required to be met. But I am not proposing to complete this plant, because the plant is complete.

So that the third course which I am going to suggest and the course which I recommend, and upon which this bill is based, seems to be the only practicable one, and that is to operate the plant with such slight additions to its machinery as to make its products more readily available as fertilizer, and by the process of continuous operation and the development of processes it may be possible in the operation to keep it constantly up to date, making it increasingly useful for the purposes of agriculture and for fertilizers, and keeping it constantly ready for any emergency of war, so that the Government may have a reliance for its explosive needs.

I think probably I need not say this, because I think everybody knows it, but history shows that every nation which has disappeared out of the civilization of the world went out by one or the other of two courses: It was either vanquished or destroyed by military processes, or it exhausted its soil and had to move. So far as I know, there is no exception of that in the history of nations.

Therefore, what we have to deal with here is a plant which is addressed to the protection of the United States against either of those courses—either its military overthrow or its agricultural exhaustion.

When you take into account the fact of the enormous investment we have in that plant, we ought then to find out whether the plant is adapted to our military reliance and whether it is adapted to a revitalizing of the soil of the country so as to prevent its agricultural exhaustion.

The **Chairman**. Is the product which is now being manufactured, Mr. Secretary, a product that is suitable for fertilizers such as are necessary.

Secretary **Baker**. The principal product which we are at present equipped to make, Senator, is cyanamid. There are many people who believe that cyanamid is in itself a fertilizer. It undoubtedly is a fertilizer, but it has not yet been accepted by the agriculturalists of the country as a complete fertilizer or an adequate and available fertilizer so that the possibility of disposing of the entire product of the plant if it were run to capacity and produced nothing but cyanamid is not at present good. But what the future of that may be, we do not know. Therefore, we are proposing to add to that additional processes and machinery to be installed which will enable us to produce the sulphate of ammonia, which is a very much better product for commercial fertilizers than cyanamid, because it is a better drillable product, less hygroscopic than the products that we are now making, than ammonium nitrate, for instance, which we make there in large quantities, and it is therefore better adapted to the commercial-agricultural fertilizer market.

The amount of Chilean nitrate which this country in prewar times has imported is estimated to be about 500,000 tons.

Senator WADSWORTH. Per year?

Secretary BAKER. Per year. My associates here have charts which show the nitrate consumption of this country from a prewar period down to the present, and forecasting the consumption up to 1930. The line of increase is steadily mounting, and they have in that chart—which is a very instructive chart—undertaken to estimate all the available sources of nitrate supply, showing what remains to be imported from Chile after we have gotten all the nitrates that we can get in this country from by-product coke-oven processes and things of that sort.

Senator SMITH of South Carolina. About what is the capacity of this plant now in the production of sulphate of ammonia, in tons?

Secretary BAKER. As soon as the sulphate process is installed, which it is proposed to install by this bill, it would be about 215,000 tons a year.

Senator SMITH of South Carolina. What percentage of nitrogen does the sulphate of ammonia contain?

Secretary BAKER. Twenty and one-half.

Senator SMITH of South Carolina. And that of the Chilean nitrate is 15 per cent?

Secretary BAKER. The Chilean nitrate nitrogen content is 15.

Senator SMITH of South Carolina. So that we would have approximately 300,000 tons on the basis of Chilean nitrate at 15 per cent?

Secretary BAKER. Yes; that is, if the needs of the country for nitrogen remain constant, we would have to import about 300,000 tons less of Chilean nitrates. As a matter of fact, the need in the country for nitrate is constantly growing, and even with the production of this great plant as proposed it is likely we would continue to import Chilean nitrate at about the same rate we do now, if we are to fill the full demands for the agricultural interests for fixed nitrogen.

Senator GORE. What do you estimate to be the additional cost of preparing this plant to successfully produce nitrogen?

Secretary BAKER. This bill is proposed to carry $12,500,000, only a portion of that, however, is for the installation of additional facilities.

And now, if I may turn to the other phase of it—Senator Gronna raised the question as to whether the Government ought itself to operate this plant or whether it ought to sell it to private individuals and let private enterprise operate it.

After studying the question very carefully we came to the conclusion that the Government ought not at present, at least, to undertake to deal directly with the ultimate consumer; that that would involve the establishment of agencies all over the United States, and we have come to the conclusion that at present we ought not undertake to do that, but that we ought to make the product and make it available under circumstances that would enable the distributors who are at present relying upon Chilean nitrate to get our nitrate and distribute it for us.

Senator NORRIS. Suppose you decide to sell the plant; have you made any investigation to discover how much you would be able to get for it?

Secretary BAKER. Yes. We believe that we can sell the sulphate ammonia at $65 a ton.

Senator NORRIS. I do not mean that; I meant the plant.

Secretary BAKER. Oh, sell the plant?

Senator NORRIS. Yes.

Secretary BAKER. Oh, no; we have not any idea about that.

Senator NORRIS. Of course, it could not be sold for anything near what it cost.

Secretary BAKER. It could not. There is only one possible concern that might buy it that anybody knows anything about, and that is the American Cyanamid Co., and they would undoubtedly want to buy it at a song. Of course, some songs are more costly than other songs, and they might be willing to buy at the cost of a high-priced song.

Senator GORE. What were the estimates as to cost in advance of commencing construction?

Secretary BAKER. Oh, very much less than the actual cost. I think $30,000,000 was the estimate for No. 2 before we started to build.

Senator SMITH of South Carolina. What did it ultimately cost?

Secretary BAKER. It ultimately cost $70,000,000.

Senator KENDRICK. I would like to ask a question which I think has a direct bearing upon what the Government would decide to do there. In effect, what would be the cost of production of this nitrate in that plant as compared to what it can be delivered here from Chile when imported?

Secretary BAKER. Those figures, Senator, are all prepared in very accurate tables here and will be put into the record by my associates, who have them arranged so that they can be followed through. But the outstanding fact was the one I was about to give Senator Gore, that we can sell sulphate of ammonia if we put in this sulphate process at $65 a ton, which is to be compared with a price for the imported Chilean nitrate of $75 per ton. The Chilean nitrate has 15 per cent of fixed nitrogen, while our product has 20 per cent of fixed nitrogen, and our product is therefore 30 per cent higher in relation to nitrogen content, and our product sells at $65 and theirs at $75 per ton.

Senator GORE. What was the price of the Chilean nitrate before the war, do you remember?

Secretary BAKER. The price varied, but my recollection is that it sometimes went as low as $55.

Senator SMITH of South Carolina. It went as low this year as $56 or $57. Before the war it fluctuated between $49 and $55. It has been some lower than that, but not after its use became general and its efficiency as a fertilizer had been established. But the price fluctuates, and it has varied this year very radically, from $56, $58, to $78. It is now quoted, delivered—that is, coming to the ultimate consumer—around $78 a ton.

Secretary BAKER. Those figures, Senator, are all in the tables which my associates have, so that the record will contain all the figures.

Senator GORE. That $65 a ton that you mentioned, is that on the cost basis? Does that allow anything for interest on the investment?

Mr. **Roberts**. We have figured here the cost price of the sulphate of ammonia, as soon as we get the water power running, as $48.22 to us, and if we sell it at $65 it will give us $16.80 profit per ton.

Senator **Gore**. Would that allow enough now on the manufacturing cost of sulphate to pay interest on the investment?

Mr. **Roberts**. Well, sir, we have figured this way, and I will answer your question. I have the figures before me. We have figured that cyanamid which can be sold—we have only calculated on using one of the units producing a very small quantity, a very small number of tons—73,000 tons of it—that is going to cost us oiled, hydrated, and made suitable for the farmer, $27, which gives $10.50 profit, because we are going to sell it at $37.50. The price of $37.50 for cyanamid means about 11 cents a pound for nitrogen, which is an extremely low price.

Senator **Smith** of South Carolina. What percentage of nitrogen is in the cyanamid?

Secretary **Baker**. It is about the same as sulphate, which ranges according to how you make it up, 19½ to 20 per cent.

Senator **Smith** of South Carolina. Available nitrogen?

Secretary **Baker**. Yes, sir; all of it is available. And on the sulphate, as I say, we make $16.80 profit. The total profit from this plant, selling at these prices, will give $2,900,000 to the Government.

Senator **Norris**. Per annum?

Secretary **Baker**. Per year.

The **Chairman**. On how large an output?

Secretary **Baker**. That is using 10 of the carbide furnaces out of 12, which will give you 73,000 tons of cyanamid, 22,000 tons of nitrate of ammonia and 107,000 tons of sulphate.

Senator **Gore**. Of course, in this business you will have to meet the Chilean competition if the price goes down; you will have to meet that competition even though you have to sell below cost.

Secretary **Baker**. Very good. Then they will have to sell their Chilean nitrate at $27 while we are getting for our cyanamid $37.50, and, as I have been informed by one of the big firms who own the mines in Chile that it can not be brought into this country under $40 without any profit to them on their investment.

Senator **Kendrick**. Do you have any estimates as to the available supply of the Chilean nitrates; are there inexhaustible quantities of it?

Secretary **Baker**. You can get reports that will range from 30 years to 300 years. So, I could not tell you. But we know one thing, that a good deal of the Chilean nitrate is at present showing borax.

Senator **Gore**. Will that ruin it for fertilizer purposes or will that have to be extracted?

Secretary **Baker**. It will have to be extracted. It will ruin it for putting on the crops.

It requires an expensive process to extract it.

The **Chairman**. I have heard nothing officially supporting what I am going to relate; it is simply rumor. But it has been told to me that the product which you have turned out does not compare with the Chilean product, and that instead of its increasing production it has rather operated the other way. What have you to say about that?

Mr. **Roberts**. This past year there was experimental work done at the Muscle Shoals plant by the Agricultural Department. I have looked over these figures, though I have not had time to study them thoroughly, because I only got them two days ago. But there is nothing in that report that shows that cyanamid is not a very good fertilizer. It has to be more carefully used than Chilean nitrate, it is true. Chilean nitrate can be made use of in a way that cyanamid can not be. In other words, that is not a safe thing to use as top dressing for wheat, while Chilean nitrate is. It is a little slower acting than Chilean nitrate, but I have no hesitancy in saying that it is a good fertilizer and that the nitrogen is available. The fertilizer people are buying it and mixing it in their goods every day. They take it from the American Cyanamid Co., and that company has been in business 10 years, gentlemen.

Senator **Smith** of South Carolina. One of the chief objections to cyanamid was due to the lime present, and it could not be handled, I mean, in putting it out, because it was very injurious to the hands. I heard quite a good deal of complaint where it was attempted to be used, just the cyanamid itself, while the Chilean nitrate, of course, can be handled and be put on as a top dressing on almost any sensitive crop, if you do not do it while the moisture—dew or rain—is on it.

Mr. **Roberts**. Yes, sir; but, let me call your attention to the fact that our principal product is going to be sulphate of ammonia.

Senator **Gore**. And that is not liable to the objection which Senator Smith of South Carolina states?

Mr. **Roberts**. That is just like gold dust, so far as selling is concerned. I can sell it and get plenty of people to sell it at 2 per cent commission. It is so easy to market it that they will sell it on a 2 cent commission basis. I have already had a big firm in New York come to me and offer to take it on that basis.

Senator **Gore**. That is true of sulphate of ammonia?

Mr. **Roberts**. That is our principal product.

Secretary **Baker**. I think I ought to say, because I want to be as frank with the committee as possible, that I am not converted to cyanamid as a fertilizer.

My associates are very much more enthusiastic about it than I am, although they know a great deal more about it than I do. But down at Muscle Shoals we planted crops in three or four plats, and we put various kinds of fertilizers on—sulphate of ammonia, nitrate of ammonia, and cyanamid; and I went down and looked at the crops, and I could see over the corn which had been grown with pure cyanamid, whereas the corn which had been grown with sulphate of ammonia and the other fertilizers which we propose to make down there overtopped that two or three times, although crops grown with pure cyanamid were very much improved over crops grown on soil which had not enrichment at all, but it was not such a fertilizer as I think we ought to bank on. Whether cyanamid can be modified so that we can use it with entire success as a fertilizer, I do not know. But from what I have seen of the results of cyanamid, I should not want this to go out in the record as recommending pure cyanamid as a complete fertilizer, because I do not believe it would pan out.

Senator **Smith** of South Carolina. Would it not be the policy of the Government even under this bill to perfect the process?

Secretary **Baker**. Now, Senator, you are striking the exact point I was just about to make in reply to Senator Gronna. He asked me why the Government itself chose to operate the plant rather than to sell it to some private individual or rely upon private enterprise. This whole business is in a nascent state. The Germans are the only people who have so developed the fixation of nitrogen as to practically free themselves from the necessity of Chilean supply. Every other nation in the world relies on Chile. The Germans practically exonerated themselves from that reliance, although during the war they did have to import large amounts of nitrates from the Scandinavian countries, where they produced it in large quantities.

From a military point of view, it is of the very greatest importance that we should not be dependent upon Chile; but from the agricultural point of view these processes are all now being developed by scientific research, and I think it is to the interest of the agricultural people of the United States to have the Government itself, which has no interest in the matter except their interest, has no commercial interest in continuing an inefficient process or in advertising an inefficient process, but has every interest in developing the best process, and that the Government itself should continue the operation of these plants and proceed with a continuous system of scientific inquiry, with the idea of perfecting the product so that it will be the very best that can be gotten for agriculture and will be produced under the most favorable conditions.

So that the proposal which we have made here is not that the Government should operate it with the so-called "red tape" of the Government—which is a phrase which I very much object to and I am sorry I have not the time to go into discussion at the present moment, because I do not think the Government has any "red tape"——

Senator **Gore** (interposing). I would not take time to discuss that now.

Secretary **Baker**. I think I will leave that aside; but in order to free this commercial enterprise from the limitations which are supposed to inhere under governmental direction, we have suggested the creation of a corporation of which the Government shall be the only stockholder, like the Panama Railroad enterprise, which operates in competition and in contact with the general industry of the maritime interests of the world; and we want to have that private enterprise operating the plant and conducting scientific inquiries, perfecting the processes, and turning out the product and distributing it to the large distributors who, in turn, will distribute it throughout the country, thus obviating the general distributing system and dealing direct with the farmers. That is the plan which this bill provides.

Senator **Norris**. Is the German system still a secret system?

Secretary **Baker**. The German system is not so much a secret system; as a matter of fact, the Germans had several systems. They had the cyanamid process, the same as we have at plant No. 2; they had the Haber process, which is in effect the process which we have at No. 1, except that they used very much higher pressure in their Haber process.

Senator **Norris**. Are we familiar with all their methods?

Secretary BAKER. So far as I know, we are familiar with every one of fixation processes which they used.

Senator NORRIS. The Germans have made themselves free from the Chilean nitrate beds, and we know all they did or do, and there is no reason why we should not do it?

Secretary BAKER. None in the world. There is no mystery, no secret; it is just going ahead.

Senator GORE. But has this outlay been due to excessive cost in the construction of the dam or equipment?

Secretary BAKER. Oh, no; the dam cost is not included in this at all. It is due to two or three things: In the first place, the original estimate of $30,000,000 was hastily prepared—a calculation upon the building of a plant the like of which had never been built, either in size or location. It is also due to the increase in cost of materials and labor which took place during the war, and due to the addition of a great many facilities and agencies in the plant which were not in the original design.

Senator SMITH of South Carolina. Mr. Secretary, the cost of construction of the plant, all the overhead charges—that is, fixed charges—must necessarily be absorbed?

Secretary BAKER. Yes.

Senator SMITH of South Carolina. But with the gradual attaining of normal conditions, the estimate made by the gentlemen associated with you of $55 a ton is looking toward the amortization of the overhead charges. But it is reasonable to suppose, is it not, that after the plant has been thoroughly operated and the labor thoroughly systematized and organized that that cost could be reduced?

Secretary BAKER. I think that is entirely possible, sir; and I think that the development of the scientific side, the research side, is exceedingly promising.

Senator GORE. Do you think that you could increase the output without correspondingly increasing the investment, so that if you would double the output you would not have to double the investment?

Secretary BAKER. Undoubtedly; and the plan, as my associates will develop it to you, is something like this: We have now a plant which is by common consent a model. The only criticism of it is whether it is too good a model; but it is by common consent a model. If we were called upon in a sudden emergency, or if the product was so satisfactory to the agricultural needs of the country as to justify it, we could duplicate the plant by putting in additional units of equivalent productive capacity without anything like doubling the expense of the installation.

Senator NORRIS. Would that be accomplished without increasing the power?

Secretary BAKER. The power problem, Senator, is complicated. At present the plant is operated by steam-generated power. We have a very large power plant down there, one of the largest power plants I know of anywhere in the world, so far as its units are concerned. There is one unit there of 60,000 kilowatts, which is equal to 80,000 horsepower. We are using that while the water power plant is being built. We ran in power lines which were coupled up with private sources of distribution of power developed on the various rivers—hydroelectric power developed by some Southern power companies. We have steam power enough of our own now to operate our plant at the proposed capacity. In the meantime the Muscle Shoals dam is being built and some day, probably very much earlier than anybody had previously supposed, we will have the great hydroelectric power of the Muscle Shoals dam across the Tennessee River, one of the most imposing water powers possibly in America.

Senator NORRIS. How much power will it develop?

Secretary BAKER. It will develop 200,000 primary horsepower.

Senator NORRIS. The year around?

Secretary BAKER. That is primary power; yes, sir.

Senator NORRIS. When that is developed the steam units will be of no consequence, will they?

Secretary BAKER. The steam units will be of consequence, because they will be used to supplement the low stage of the river.

Senator NORRIS. Then the horsepower developed by water power that you have given applies only to the maximum and not to the steady flow?

Secretary BAKER. That was the primary power. Then, in addition to that, they have 200,000 horsepower secondary power.

Mr. ROBERTS. They claim it can go up to 400,000, but that 400,000 can only be used, a part of it, for six months.

Senator NORRIS. What proportion of the year can you develop that 200,000—every day?

Mr. ROBERTS. Well, sir; I will tell you—I will have to answer that this way: We have got it all here in detail that we are going to present to you. But the river does have some few days in some years when it gets down as low as 70,000 kilowatts. I have to think in kilowatts, because all the power is measured in kilowatts, and a kilowatt is 1⅓ horsepower. You see, 75,000 kilowatts is exactly 100,000 horsepower. For a short period of time we will have to run the steam plant. It is figured that if we supply industry on the 8-hour basis or two-thirds, if we were going to sell that power to industry the best way to do it——

Senator NORRIS (interposing). What I am trying to get at is your maximum and the minimum power. In the driest day of the driest year during the time the stream has been measured, how low would the horsepower be?

Mr. ROBERTS. I think it has gotten down as low as 89,000 horsepower.

Senator NORRIS. It varies from that up to how much—what is the maximum now, the very best?

Mr. ROBERTS. I really could not tell you about what that would be; probably about 500,000 horsepower.

Senator NORRIS. It varies a great deal more than Great Falls, does it not?

Secretary BAKER. Very much more.

Senator NORRIS. So it is necessary to have auxiliaries at these plants?

Secretary BAKER. It is necessary, but Mr. Roberts has not quite developed, as it seems to me, the situation there. This dam is a storage dam, so that we are not dependent upon the lowest stage of the river for that day's run. Back in the hills of that valley there are great storage reservoirs, which will be filled up by the dam, and we will have a continuous development of power. They have here the figures, and it is idle for me to attempt to recollect them.

Senator **Norris**. How far is the storage dam from the power development?

Secretary **Baker**. Immediately adjacent to it.

Senator **Gore**. Do you have to haul your coal?

Secretary **Baker**. Yes; some distance, not very far; it is southern coal, all of it.

The **Chairman**. The cyanamid process is a patented process, is it not?

Secretary **Baker**. It is a patented process.

The **Chairman**. I take it that during the war perhaps, it was turned over to the Government without any charge?

Secretary **Baker**. I think not. We had a contract with the American Cyanamid Co. to build that plant and operate it under certain terms of royalty. Those figures are available as to the amount they should receive; it was a low price.

The **Chairman**. The reason I asked that is because this committee had rather extensive hearings when Senator Gore was chairman, and we had before us Mr. Washburn, who is very well posted on this matter.

Secretary **Baker**. He is the president of the American Cyanamid Co.

The **Chairman**. He went into these questions somewhat in detail, and he told the cost of water power. For instance, that in the Scandinavian countries, especially Norway and Sweden, that the horsepower cost only about $4.50, whereas in this country at that time it cost about $18 to $19, as I recollect. Of course, we could not compete with those countries. While I know so little about water power and absolutely nothing about these processes of manufacture, I can see from a business viewpoint that under those conditions it would be impossible for us to compete in the manufacture of the raw product without reducing the common nitrogen into nitric acid, which necessarily must be done before it can be used. As I understand it, it is a very simple process to extract nitrogen from the air; all that is required is heat and power—that is, power to make the heat—and plenty of water.

Secretary **Baker**. It is simple only in the sense that it is understood, but it is about as complicated a physical and chemical reaction as you ever saw, Senator.

The **Chairman**. A friend of mine by the name of Capt. Eyde invented the arc process. I do not know whether you are using that.

Secretary **Baker**. We are not using that. That is for producing pure nitric acid.

The **Chairman**. He lived in the city of Chicago, and went back to the old country and secured a small amount of capital in France, and they just barreled up hundreds of thousands of barrels at one falls where they have 600,000 horsepower, and they can make it at such a low price that I do not see how we can possibly compete with them in the manufacture of nitrogen unless we put a tariff on the product of 200, 300, or 400 per cent.

Secretary **Baker**. You mean manufacture nitric acid at such a low price by the arc process?

The **Chairman**. Yes.

Secretary **Baker**. Those facts I do not know about.

The **Chairman**. I only offered that for the purpose of having it considered. I have all the data with reference to the manufacture of nitric acid in the Scandinavian countries. They have hundreds of those plants over there, and it does not seem to me we can possibly compete.

Senator **Norris**. They are all operating with water power, are they not?

The **Chairman**. They produce entirely by water power.

Senator **Norris**. And their water power is very cheap?

The **Chairman**. It costs them from $4 to $5 per horsepower.

Secretary **Baker**. Even when you make nitric acid by the arc process, you would have to convert it into some form in which you can transport it, so that it would be necessary to revise the figures, Senator.

The **Chairman**. They are making it into saltpeter, making it into solids and barreling it up. There is no doubt about that.

Secretary **Baker**. We had the figures of the arc process; I saw them once. It was the cheapest of all processes, if you consider the low cost for the manufacture of pure nitric acid, but it was the most expensive of all the processes if you had to pay anything for the power. It uses more power. It is almost entirely a power process, and its consumption of electric current is enormous.

The **Chairman**. But inexpensive in that country, so Mr. Washburn informed us.

Secretary **Baker**. I think he is right about that. I have tried to state the importance of the product, both from the point of view of protection of the Government in times of war and its importance to agriculture. I have given my own view as to why it is better for the Government to conduct this than to turn it over to private individuals.

And now comes the question that undoubtedly will impress Congress most, and that is the cost of it. This bill undertakes to carry $12,500,000, and I know there will be very great reluctance on the part of Congress to spend $12,500,000 for any project, which is a very proper reluctance, with which I have complete sympathy.

We have figured in the War Department that the necessary safety reserve of Chilean nitrate for us to keep on hand against an emergency is 300,000 tons, and we have sold the Government's surplus stocks of nitrate down to 300,000 tons, or we are in process of doing it. We have now figured in the War Department that if this plant is kept going, and in addition to that we can rely upon it in an emergency to produce half of what would otherwise be required to keep as a safety reserve, in other words, if this plant is continued according to the plan proposed here, we will be required to keep on hand only 150,000 tons rather than 300,000 tons.

I am going to ask you, therefore, to bring in a committee amendment to this bill which will authorize the War Department to dispose of 150,000 tons of the nitrate which it has in hand and use that money, instead of a fresh appropriation of $12,500,000, to carry out the purposes of this bill.

Senator **Norris**. How much money will that bring you?

Secretary **Baker**. It will bring us $12,500,000. We can sell 150,000 tons and get enough money to put in the additional appliances, have the working capital and keep the company going until it begins to earn.

Senator **Norris**. That would save any appropriation, then?

Secretary **Baker**. It would save us the necessity of any appropriation.

Senator **Smith** of South Carolina. I would like to say, Mr. Chairman, that I got an appropriation of $20,000,000 to purchase Chilean nitrates for the farmers during the war, and it was made a revolving fund. That was handled by the Agricultural Department. The demand for it was so great that they sold it all, and the Government had all the appropriation, and was reimbursed with all the expenses attached, so that the $20,000,000 is back in the Treasury without a cent's loss to the Government. That was one time when the Government appropriated money and got every cent of it back without any loss.

Senator **Capper**. Mr. Secretary, what would be the chances for this project being self-supporting after you got it started?

Secretary **Baker**. We believe it will be self-supporting from this on. We have asked for a $12,500,000 capital, which we believe will carry the project on until its net earnings recoup, and from then on it will be continuously self-supporting.

Senator **Gore**. Will there be other sources of revenue from the sale of power?

Secretary **Baker**. There will always be the possibility of selling power. Of course, the power will have to be fed into the lines that run all through that part of the country.

Senator **Norris**. Do you possess now, without additional legislation, the necessary authority to organize the kind of a corporation you were speaking of awhile ago?

Secretary **Baker**. No, sir; this bill carries that.

Senator **Norris**. That is in this bill?

Secretary **Baker**. Yes, sir.

Senator **Smith** of South Carolina. The original bill provides that the Government should operate the plant for munition purposes and sell the surplus in such form as it might see fit to put it, practically at cost to the Government.

Secretary **Baker**. The amendment I am proposing is to strike out the sentence which reads:

> And there is hereby appropriated the sum of $12,500,000, or so much thereof as may be necessary, for the purpose of making payment upon such subscription when called—

And substituting therefor the following:

> In order to pay such subscription as and when called, the Secretary of War is hereby authorized to sell so much as may be necessary of the supply of nitrate of soda owned by the United States and held as a reserve by the War Department at such prices and under such regulations as may be prescribed by the Secretary of War. All sums realized from such sale are hereby appropriated to the use of the Secretary of War for the purchase of the preferred stock of the corporation.

Of course, the committee will understand that the War Department does not feel that it would be safe in reducing its stock of 300,000 tons of nitrate to 150,000 tons upon any other condition than that the possibilities of this plant for emergency reliance is kept constantly available.

Senator **Norris**. Why do you say "preferred stock"?

Secretary **Baker**. The plan of the bill requires that the existing facilities shall be covered by common stock which shall all be the property of the Government in the same way.

Senator **Norris**. Why have two kinds of stock, if the Government owns it all, anyway?

Secretary **Baker**. I am sorry I can not answer that. The lawyers worked it out, and I did not pay much attention to it.

Senator **Norris**. I suppose the lawyers were so used to drawing up articles of incorporation where there was some manipulation of stock and two or three different classes of stockholders that they followed a habit?

Secretary **Baker**. I am informed there are a hundred shares of the common stock and the theory is to have the Secretary of War hold 95 and put qualifying shares with the Secretary of Agriculture and the Secretary of the Interior, and so on.

Senator **Norris**. That is all right. But there is no reason for this other stock, if the Government owns it all.

Secretary **Baker**. There is no reason——

Senator **Norris** (interposing). Of course, it will all belong to the Government?

Secretary **Baker**. Surely.

Senator **Norris**. Then why have two kinds of stock?

Secretary **Baker**. The Government owns it under what we call a corporate form of organization, so that it can deal with the express companies and freight companies as private companies.

Senator **Smith** of South Carolina. This bill contemplates the Government owning and controlling the operation of this plant through this organization?

Secretary **Baker**. Yes, sir.

Senator **Smith** of South Carolina. In that way do I understand that the Government will largely, if not entirely, determine the selling price of the stock?

Secretary **Baker**. Yes, Senator.

Senator **Smith** of South Carolina. It has just occurred to me in connection with the suggestion you made about selling 150,000 tons of sodium nitrate—Chilean nitrate—out of the reserve you have, that it is a wise proposal, for, as every one knows, in storing nitrate of soda it deteriorates, with the affinity that ammonia has for moisture, and causes a loss. There would also be a loss to the Government in carrying it. It seems to me that from that standpoint it would be a good business proposition if the Government was to dispose of half of it, especially at this time when there is such a need for all the nitrates that can be gotten for purposes of agriculture.

Secretary **Baker**. It has the advantages you refer to, Senator, of getting out of stock 150,000 tons, which would be subject to some loss by deterioration; and, of course, it involves the great saving of obviating the necessity of building warehouses and sheds for the permanent preservation of it.

Senator **Wadsworth**. Mr. Secretary, where is that stored?

Gen. **Williams**. We have a lot stored at Rock Island and a lot stored at several Atlantic seaboard points.

Senator **Wadsworth**. In what type of construction is it stored?

Gen. **Williams.** At Rock Island it is stored in hollow tile buildings, of permanent character; and at the seaboards, it is stored now, I think, in rented warehouses of any kind that were available, that would be suitable for the purpose.

Senator **Norris.** How much have you stored at Rock Island?

Gen. **Williams.** I can not give you the exact figures on that.

Senator **Norris.** Have you any idea as to the amount that is stored in buildings owned by the Government in fire proof construction, as compared to the amount that is in rented storehouses?

Gen. **Williams.** I think perhaps we have about 100,000 tons stored in that way.

Senator **Norris.** I suppose if the department was authorized by this bill to dispose of 150,000 tons it would dispose of that part of it which you have in rented storehouses?

Gen. **Williams.** Yes, sir; quite so.

Senator **Wadsworth.** Can you give any general figures, General, of what your carrying charges are on the stuff that is stored in rented storehouses?

Gen. **Williams.** Our estimates are that by the sale of this 150,000 tons we would save for the Government about $1,800,000 in construction cost for storage buildings, and in freight from the present locations at the seaboard to the interior where we would store it.

Senator **Smith** of South Carolina. About how much?

Gen. **Williams.** About $1,800,000.

Senator **Smith** of South Carolina. That includes the value of the sodium nitrate?

Gen. **Williams.** No; we would have to construct certain buildings, which we would locate in the interior of the country, and then we would have the freight expense on the shipment of sodium nitrate from its present locations at the seaboard to the central parts of the country, and the total cost is estimated at about $1,800,000.

Senator **Wadsworth.** Do you happen to recollect what rentals you are paying now?

Col. **Burns.** The detailed estimate shows storage charges for six months' commercial storage for the amount in such storage of $91,000.

Secretary **Baker.** That is on the total stock?

Col. **Burns.** That would be for part of the 150,000 tons, and the corresponding Government charges for the remainder would be $38,000.

Senator **Smith** of South Carolina. The $91,000 you are paying these private corporations for the use of warehouses?

Col. **Burns.** That is for storing sodium nitrate until new warehouses can be erected. We have it divided into two parts, commercial storage and Government storage.

Senator **Smith** of South Carolina. I presume the insurance on it is very high. It is the most inflammable thing in the world.

Gen. **Williams.** We do not carry any insurance.

Senator **Smith** of South Carolina. I mean in these private storehouses where the nitrates are stored.

Gen. **Williams.** I can not tell you about that.

Secretary **Baker.** I do not think it is inflammable.

Senator **Smith** of South Carolina. Sodium nitrate?

Secretary **Baker.** I should not think so.

Senator **Smith** of South Carolina. You stick a match to it and see.

Secretary **Baker.** Col. Burns, is it inflammable?

Col. BURNS. No, sir; it is not except in contact with carbonaceous material. In other words, if you have a bag of sodium nitrate, the bag will burn very rapidly, but if you have no such material, such as bagging or wood with the sodium nitrate, I do not think you can burn it. We have a chemist down here, Col. Lamb, who agrees with me.

Senator NORRIS. I never knew questions to be determined by experts in my life but what there were disagreements. [Laughter.]

Secretary BAKER. I have covered all the observations I have to make, and I would now like to have the committee hear the experts.

The CHAIRMAN. Are there any questions any Member wishes to ask the Secretary?

Senator KENDRICK. Mr. Secretary, you spoke a moment ago about the power site; you mentioned the dam and the possibilities of developing water power in that way. Does the Government at this time own the site of this proposed power plant, and has it carried out all the necessary plans for controlling that situation?

Secretary BAKER. The Government owns practically the entire site. There is a small piece of ground which was offered to the Government by some private owners in Alabama on condition that the Government would not go into any commercial use of the power, and I declined to accept it with that limitation, and that, as I understand, is in process of condemnation proceedings.

Senator SMITH of South Carolina. Then, I understand that the Government owns the entire site?

Secretary BAKER. The Government owns the entire site where these plants are, and it owns the site where the dam is in process of construction, and the dam is now being built by the Engineer Corps.

Senator SMITH of South Carolina. How many acres of land are owned by the Government?

Secretary BAKER. I should say 200.

Mr. ROBERTS. We use 2,200 acres at Plant No. 2, but I do not know about the dam flowage rights.

Secretary BAKER. The flowage rights are covered but the site consists of the large number of acres Mr. Roberts is speaking about.

Senator KENDRICK. So that there would be no complications in carrying out that part of it?

Secretary BAKER. No.

The CHAIRMAN. Then, as I understand it, Mr. Secretary, your recommendation is that we change the bill so that it will authorize the completion of the organization of the corporation, and then authorizing the Secretary of War to sell the sodium nitrate you have on hand, so that the bill would really carry no appropriation at all.

Secretary BAKER. It carries no appropriation at all, and I will leave the proposed amendment with the committee.

Senator KENDRICK. What was the original estimate of the cost of the dam?

Secretary BAKER. The original estimate was $10,000,000, but the high cost of labor and materials became such that we are now restudying the project, and it will undoubtedly be much larger than that.

Senator SMITH of South Carolina. The only change, you say, is the amendment looking to the disposition of 150,000 tons of sodium nitrate now on hand?

Secretary **Baker**. Yes, sir; and I will say with regard to the corporate form adopted, that I trust that the committee will not take my unfamiliarity as condemnation of the proposal. I think that the purpose was to have stock issued which would represent the money put into the plant from time to time as the basis of determining what income the Government could get as a part of the fair cost of production in determining the price of the product from time to time.

Senator **Norris**. You do not need to have two kinds of stock to do that. There is really no use in having two kinds of stock unless you want to give the holders of one kind of stock an advantage over the others, some kind of manipulation.

Senator **Gore**. For bookkeeping purposes, might it not be necessary?

Senator **Norris**. I do not see why. If you want to issue stock to the Government for what it cost, it would only be a matter of paper and a little printing.

Senator **Gore**. I observe the high cost of living affects the dam site as well as other propositions.

Secretary **Baker**. It affects us all the same way.

Senator **Wadsworth**. Is the stock to be assessable?

Secretary **Baker**. The law provides, as I remember, that no money can be put in except as authorized by this act or subsequent acts of Congress.

Senator **Norris**. The Government would not have any object in assessing itself.

Senator **Smith** of South Carolina. Mr. Secretary, how soon would the plant be sufficiently perfected to begin to produce this sulphate of ammonia or the fertilizer form of this nitrogen for sale in commercial quantities?

Mr. **Roberts**. Just as soon as we can put in our sulphate of ammonia process, which, under the present conditions, we would say would be six months.

Senator **Smith** of South Carolina. So that if this bill should become law and the company is organized, you would be ready by the next season to begin to put on the market your product?

Mr. **Roberts**. Yes, sir.

Senator **Smith** of South Carolina. And about how many tons do you think you could reasonably expect to put on the market in that length of time?

Mr. **Roberts**. Well, you see, it is this way: We start out and gradually build up our plant, and we would get at the end of the first year up to about 86,000 tons of sulphate of ammonia and 22,000 tons of nitrate of ammonia; and besides, we could sell something like 30,000 tons of cyanamid to some of the fertilizer mixers. The fertilizer mixers can to-day probably absorb about 60,000 tons of cyanamid. But, of course, the American Cyanamid Co. would probably supply half of that. You know it is being used daily in the mixture of fertilizers.

Senator **Smith** of South Carolina. The object I had in view in answer to that question is that the farmers generally, where a "balanced fertilizer," as they call it, is used, potash, phosphoric acid and nitrogen—buy it in as concentrated a form as they can and mix it themselves. They find they save freight and save expense. You take muriate of potash, it is high in its percentage of potash. Nitrate of soda is the highest form we have been able to get of nitrogen, and it is easily handled; and then they get 17 per cent phosphoric acid. Then, when they mix it they do not carry that tremendous filler. You take the ordinary commercial fertilizer, known as 8–3–3—8 per cent phosphoric acid, 3 per cent ammonia, and 3 per cent potash—and you get a minimum of the ingredient you want in a 200-pound sack, and that balance of weight is just a mere filler to contain these ingredients in a fixed form. So it is to the interests of the agricultural people to get these ingredients in as concentrated form as they may, mix it in a balanced form as they see fit, and save freight. That is the reason I asked what time you could get your 20 per cent sulphate of ammonia in available form for use of the agricultural people, because the cyanamid has to be mixed by these commercial fertilizer mixers, who take the cyanamid and mix it by machinery, whereas the agriculturists mix it by hand in their sheds and farm buildings.

Mr. ROBERTS. Of course, we are in position just as soon as we get the sulphate plant ready to make it up to 100,000 tons of it. Yet, we have got to develop the sale of it.

Senator KENDRICK. Mr. Roberts, do you feel sure that if your plans miscarry in the matter of increase of competition from imported nitrates that you can, at the very least, secure enough returns from this plant to perpetuate its operation?

Mr. ROBERTS. I presume when you say "our plans miscarry," you mean we can not produce it as cheaply as we figured on.

Senator KENDRICK. Yes, as economically.

Mr. ROBERTS. I do not feel any hesitancy in saying that we have made liberal estimates. We have our estimates which we will present to you in the greatest detail, so far as that goes. We also have got here in our sulphate ammonia $16.80 profit to go and come on, and we certainly will be self-sustaining in any condition I can conceive of.

Senator KENDRICK. I ask the question for the reason that it has impressed me if we could be reasonably safe we could perpetually operate the plant in the face of competition that it would undoubtedly be a very great thing for the Nation to carry out this project for its own protection, both in the way of fertilizer and in the matter of explosives.

Mr. ROBERTS. There is no doubt in my mind, sir, at all that this plant can more than carry itself. I feel no hesitancy in saying that. I certainly expect it to make $3,000,000 a year.

Senator WADSWORTH. What effect do you think it will have on the chemical fertilizer industry of this country?

Mr. ROBERTS. None. The demand for nitrogen is growing right along, and we will have to import larger and larger quantities of Chilean nitrate, even with this plant running.

Senator WADSWORTH. There is room for everybody?

Mr. ROBERTS. There is room for everybody. Mr. Myers, who represents the Chilean nitrate industry in this country, says the demand for nitrogen is going to be so great that this would not affect his interests at all.

Senator WADSWORTH. What are his interests, do you say?

Mr. ROBERTS. The importation of sodium nitrate into this country, and he made that statement before the Graham committee. We will not interfere with any private interests at all; there is plenty of room for all of us.

Senator SMITH of South Carolina. That is the ingredient in all fertilizer that is not only in greatest demand but it is the costliest.

Mr. ROBERTS. Yes, sir.

Senator SMITH of South Carolina. Nitrogen, as every agriculturist knows, is the very life of the grain itself. It is not so important in the fibrous plants, but for cereals of all sorts with the proper use of nitrogen the crops can be doubled and, in some instances, quadrupled.

Mr. ROBERTS. I know of nothing, sir, that does not require nitrogen just as much as grain. Tobacco certainly requires it and you can not successfully grow tobacco without it. Certainly your truck gardens could not exist without it.

Senator SMITH of South Carolina. Certainly; the truck gardens need it just as much, but in the production of tobacco and cotton it is not so important.

Mr. ROBERTS. I have to differ with that statement, sir. As a tobacco grower, I know we do not use it to a great extent. I state that from practical experience.

Senator SMITH of South Carolina. With us we use phosphoric acid and potash as the ingredients that produce the best results in tobacco; and while nitrate will stimulate the growth of cotton, and in that way directly add to the production of fiber, but only by increasing the plant. Nevertheless in all forms of grain raised down in the southeastern section, in the coastal plain, from Virginia to Florida, it is practically impossible to raise anything like what we call a full crop of corn, oats, wheat or any of the cereals without a liberal application of nitrogen.

Secretary BAKER. May I make a parting suggestion?

The CHAIRMAN. Yes, sir.

Secretary BAKER. The room is full of experts and they are full of information. I do not know how much scientific data the committee wants or how complete a record you desire to make. It is hardly fair to ask judges how they are going to decide the case. But I want to have no defect in this record, and yet I do not want the committee to hear an elaborate exposition of scientific statements unless they want them. The committee can take these experts in series and have each one testify and put into the record their statements, or if there are branches of the case which you do not want to hear orally we can put memorandums into the record which will make a complete exposition of the subject.

The CHAIRMAN. I think the committee will be glad to hear from these experts. Of course, we are pressed for time, but we could probably sit this evening if some of these gentlemen would care to come. We will not be able to get through this afternoon, that is apparent.

Senator KENDRICK. Could we not have another session to-morrow morning?

The CHAIRMAN. Not to-morrow morning, because then we are going to take up the subject of cold storage.

Senator NORRIS. Then I suggest that we go ahead and hear as much as we can until 12 o'clock.

STATEMENT OF MAJ. GEN. CLARENCE WILLIAMS, CHIEF OF ORDNANCE, WAR DEPARTMENT.

The CHAIRMAN. You may proceed in your own way, General, and give us such information as you may care to.

Gen. WILLIAMS. I have a prepared statement here that I should like to give the committee, if I may. We are, of course, greatly concerned with nitrogen, because of its exceeding military importance, and one can easily picture the importance of it by thinking of what Germany would have been without the process of fixing nitrogen from the air, which they already had established. Germany could not have carried on the war for six months except for her preparation in that regard.

In the early days of the use in the United States of inorganic nitrogen for explosives, fertilizers, and chemicals, we were practically 100 per cent dependent upon importations from one country or another, but especially from Chile. In 1916, although we had gradually increased the production of fixed nitrogen mainly through the construction of by-product coke ovens, we were still some 75 to 80 per cent dependent upon importation. Congress in the national defense act of June 3, 1916, appropriated $20,000,000 for the investigation and development of processes for the fixation of atmospheric nitrogen for munitions of war or useful in the manufacture of fertilizers and other useful products, the construction of plants, the development of water and other power necessary thereto, and for the operation of such plants for military, naval, and other domestic purposes. In accordance with this legilsation the President, through the Secretary of War, appointed various commissions and committees to study the nitrogen fixation problems and to recommend the steps that the War Department should take in order to carry out the provisions of the act.

As the committee probably knows, there are various methods of fixing nitrogen, all of which have certain advantages and disadvantages. A description of these various processes, together with the advantages and disadvantages thereof, will be presented to the committee by another witness.

By the early spring of 1917 these studies had so far progressed that the final committee was able to make certain definite recommendations which they included in the program and submitted to the Secretary of War. The Secretary of War in turn delegated the task of carrying out this program to the Ordnance Department as far as the chemical activities were concerned. The outstanding feature of the program was the construction of a synthetic ammonia plant, using the General Chemical Co.'s process. After considerable study as to the proper location a site was selected at Sheffield, Ala., and a plant started in the fall of 1917. It was scheduled to fix sufficient nitrogen in the form of ammonia for 22,000 tons of ammonium nitrate. It was to be provided with facilities for oxidizing part of the ammonia into nitric acid for concentrating some of the nitric acid up to the strength of 94 per cent, and of combining nitric acid and ammonia to ammonium nitrate. The plant had been substantially completed at the time of the armistice at a cost of $13,000,000.

The entire ammonia production, however, during the period of attempted operation was very small, and the process never operated with any regularity due to mechanical and catalyst troubles. The remainder of the plant functioned successfully. At the time of the armistice the belief existed and still exists that after further study and modifications of design and process synthetic ammonia can be successfully produced at this plant. Thorough research is now under way in an effort to solve the troubles, and engineers are at work laying down the design of a new small-scale unit, and it is hoped that satisfactory results will be obtained.

Senator NORRIS. At this point, are you going to tell us why there was a failure?

Gen. WILLIAMS. That will be brought out by the other witnesses.

Senator NORRIS. All right.

Gen. WILLIAMS. It was a failure in this new process where the nitrogen and the hydrogen are welded together to form ammonia. It was a modification of the Haber process and worked at the lower temperature and at a higher pressure, but it was not correctly designed, and while we fixed some nitrogen the output was so small that we could not consider it a success. That can be fully developed by witnesses who will go into all of the details.

At approximately the same time work was started on the hydroelectric development in the Tennessee River at Muscle Shoals, Ala., for the development of the power necessary to fix the nitrogen. The work was placed in the hands of the Corps of Engineers, United States Army, and the dam is now in the process of construction. It will hardly be completed before 1923. The dam will undoubtedly develop a primary horsepower of 100,000 and the United States Engineers' report indicates that this primary horsepower may reach 200,000.

Senator NORRIS. What do you mean by "primary horsepower"?

Mr. ROBERTS. Primary horsepower is the horsepower that can be developed for every hour during every day in the year; it is the constant power.

Senator NORRIS. I understood it that way, but I desired to have the record show that. In reality, there is no difference between "primary horsepower" and "minimum horsepower"?

Secretary BAKER. Continuous minimum horsepower.

Senator NORRIS. Continuous minimum horsepower only means that much horsepower that could be developed at the very lowest stage of the water?

Gen. WILLIAMS. Yes.

Senator NORRIS. For one day?

Mr. ROBERTS. No; that is a limitation upon "primary horsepower" that would not be correct. We would say you might get in any one year a week in which that would not be true, and you might, for instance, get a very great drought which would cut your horsepower down for a week; but we would not take that into account in primary horsepower.

Senator NORRIS. You have to base your estimates on the measurements for the length of time the stream has been measured?

Mr. ROBERTS. If it would fall below only for a week, we would not count that.

Senator NORRIS. You would not count that?

Mr. ROBERTS. No.

Senator NORRIS. Still, if that occurred you would be out of business?

Mr. ROBERTS. For that week?

Senator NORRIS. Yes, sir.

Gen. WILLIAMS. Except that we have the steam plant to supplement the water power.

Senator NORRIS. I mean without any supplemental steam plant. In figuring on Great Falls they found it only went down once in 15 years during which it was measured.

Mr. ROBERTS. As the minimum horsepower?

Senator NORRIS. Yes.

Mr. ROBERTS. But not as the primary?

Senator NORRIS. I do not understand then what good the use of the term "primary horsepower" can be. Suppose it went below for two weeks. Would that still be "primary horsepower?"

Mr. ROBERTS. We have always thought anything over a period of 20 years that if you got one week—you take the average lowest parts of a period of 20 years and call that the "primary horsepower."

Senator NORRIS. Has that stream down there been measured for 20 years?

Mr. ROBERTS. Oh, yes.

Senator NORRIS. Great Falls has been measured for 15 years.

Gen. WILLIAMS. During the fall of 1917, when our munitions program developed into such gigantic quantities, we were forced to adopt amatol, or a combination of T. N. T. and ammonium nitrate, as our explosive for bursting charge in order to meet demands. This policy required the building of large ammonium nitrate plants. At this time we were having trouble in obtaining sodium nitrate, due to shortage of ships that could not be spared to make the haul from Chile. We were also short of ammonia, due to the very large demand for refrigeration, domestic explosives, and other necessary materials. It was therefore decided to put up a fixation plant that could combine the nitrogen of the air into the form of ammonium nitrate and thus eliminate, to the extent of the production capacity of the plant, the importation of sodium nitrate and the taking of ammonia from the already short supply.

No. 1 plant was really of an experimental nature and was for the purpose of developing the most economical method. We were now face to face with war needs and it was necessary to adopt a proven process. The American Cyanamid Co. had such a process, namely: The cyanamide process, in their plant at Niagara Falls, Canada. We therefore adopted this system of fixing nitrogen in order to be sure of quickly and successfully meeting our demands. A contract was entered into with the American Cyanamid Co. in November, 1917, and a plant—No. 2 plant—started at Muscle Shoals, Ala., for the manufacture of 220,000 tons of cyanamid per year and the conversion of this into ammonia, nitric acid, etc., and the formation therefrom of 110,000 tons of ammonium nitrate. This quantity of cyanamid would contain some 45,000 tons of fixed nitrogen or the equivalent of 270,000 tons of Chilean nitrate—nearly one-half our yearly prewar importations from Chile and sufficient to feed some 15 divisions of a war army with powder, explosives, etc. At the time of the armistice it was practically completed at a cost of $60,000,000. A small-scale operating test was completed after the armistice which indicated that the plant with very minor exceptions was very satisfactory and could turn out full quantities of good material at reasonable costs.

Subsequently two other plants were started which were to use this same process—one at Toledo, Ohio, and one at Cincinnati, Ohio—each to have a capacity of 55,000 tons of ammonium nitrate per year. At the time of the armistice each was approximately one-third completed and the decision was reached to stop work and to turn the plants over for salvage. The total expenditure of these two plants, if completed, would probably have equalled $60,000,000.

There was also undertaken during the war a plant for the fixing of nitrogen through the sodium cyanide, or Bucher, process. It was built under the direction of the Bureau of Mines, at Saltville, Va., and was called United States Chemical Plant. It was to have a capacity of 10 tons of sodium cyanide per day, and this material was to be used in the manufacture of poisonous gases. Construction was started in March, 1918, and was substantially completed at the time of the armistice, at a cost of some $2,250,000. The plant was not a complete success, although it was operated sufficiently to prove that nitrogen can be fixed by this method. The cost, however, of fixing nitrogen by this process seems to be prohibitive. Control of the plant was returned to the Ordnance Department shortly after the armistice, and, inasmuch as there was no further need for it, recommendation was made that it be salvaged, and such action was undertaken.

It is thus seen that, even with our control of the seas, we were forced during this war to launch a building program for the fixing of nitrogen which would have cost us $160,000,000.

It shall be noted here that the above undertakings, all directly financed and controlled by this Government, represent almost the entire construction development in this country of the art of nitrogen fixation.

Senator NORRIS. Why was that a failure? As I understood, these processes were well known and that you knew just how the Germans did it.

Gen. WILLIAMS. We found the cost prohibitive.

Senator NORRIS. Was not the department able to know that before they expended the money, if they knew all about it, that the cost would be prohibitive?

Gen. WILLIAMS. No; I do not think they knew it.

Senator NORRIS. Then they did not know what Germany knew?

Gen. WILLIAMS. They did not know the details of what Germany knew; they had general information, but not the detailed information about it.

Senator NORRIS. Do they know that now?

Gen. WILLIAMS. I do not think we know all of the details of how they carried that out.

Senator NORRIS. The point seems to me to be that if we did know it why we should start so many times and make a failure. If we have made a failure, we have not yet discovered the right process.

Gen. WILLIAMS. It is the same in the manufacture of certain other materials. Take, for instance, the French 75-millimeter guns. We knew perfectly well what the French 75-millimeter gun was; we had the drawings of it. We knew all of the details, and we had Frenchmen to help us. But there was nobody in this country who could possibly estimate the cost of manufacturing the French 75-millimeter guns.

Senator WADSWORTH. Under our shop methods?

Gen. WILLIAMS. Under our shop methods. The English could not have done it, and the Italians could not have done it, and so it is with these other things.

Secretary BAKER. The only process which has disappointed us at all was the Haber process, at plant No. 1, where we undertook to modify what we knew to be the German practice. They used very high pressures and lower temperatures. We undertook to use lower temperatures with less pressure.

Senator NORRIS. Then the failure came because you did not follow the German process?

Secretary BAKER. In that case I think that is so.

Senator NORRIS. What was the failure at Toledo?

Secretary BAKER. There was no failure at Toledo and none at Cincinnati. Those plants were in process of construction and had only gotten so far at the time of the armistice.

Senator NORRIS. What was the cause of the failure in Virginia?

Secretary BAKER. At Saltville it was the cyanide process, which has never been worked out successfully by the Germans or anybody else. That was the process we adopted because from this cyanide gases were manufactured, and while it was a perfectly valuable process for the production of gases, it was not economical for the fixation of nitrogen.

Gen. WILLIAMS. I would like to make plain that the knowledge of the process—having that, it does not follow that you have the knowledge of commercially producing this stuff. It is only when you get an organization and trained men that you can produce it successfully. We know the process theoretically very well.

The CHAIRMAN. As I understood you, General, you do have that knowledge in respect of the cyanamid process, but not about the others.

Gen. WILLIAMS. We sent a committee over to Europe to look into that and get what information they could about the operation of the Haber process in Germany. I do not think it at all follows that because they have been to the works, as they did go and look over and see all the arrangements the Germans had, that they can come back here and install the same organization and equipment.

Senator NORRIS. But it does not follow they know all about it. The Germans made a success of it?

Gen. WILLIAMS. They made a success of it after a long trial and developing a trained personnel.

Senator NORRIS. And yet we have not succeeded?

Gen. WILLIAMS. No; we have not as yet.

Secretary BAKER. I do not like to allow that to go into the record unqualified that the Germans made a complete success of the Haber process. There are people who claim they did. The fact is that while the Haber process was not an unqualified success, yet they used it and produced about 50 per cent of the total production of nitrogen they consumed with it. But whether it was able to stand on its feet in competition with the cyanamid process is still to be ascertained. They used it because of the necessities of their situation.

Senator UNDERWOOD. During the war, when we were developing these various processes for war purposes, we were not considering the cost at all; it was merely a question of producing results. But now it has gotten down to a commercial proposition, and cost is very material.

Secretary BAKER. Within proper limitations, we were not considering cost. I do not want to make a damaging admission. [Laughter.]

Senator UNDERWOOD. The cost was not the prime object.

Secretary BAKER. Cost was not the prime object; no, sir.

Gen. WILLIAMS. The very important thing was for us to put in a process that we knew would give us results, and that was the only process that we considered that we had sufficient knowledge of that we could install and certainly produce results.

Senator KENDRICK. I wanted to ask Maj. Gen. Williams, in connection with that, if the department had not in other instances changed the German methods and improved upon them. Have you not, in other cases in this manufacture changed the German method and somewhat improved it?

Gen. WILLIAMS. In the fixation of nitrogen?

Senator KENDRICK. Yes.

Gen. WILLIAMS. Not so far as I know. The experts can tell you more about that.

Senator GORE. I was wondering if there had been any developments because of the change of plan.

Gen. WILLIAMS. That is a question that I personally am not able to answer, and I would much rather you would call on some of the experts that we have here to give you detailed information.

Senator KENDRICK. I would suggest here in direct connection with Senator Norris' question, that I am reminded of a statement made on the floor of the Senate by Senator Frelinghuysen in reference to the production of dyes; and, as I recall his statement, there were many failures to begin with where they seemed to know all about this process of dye stuff production, and when they finally succeeded it was when they discovered the fact that a change in the number of revolutions of their machinery accomplished the production of those dyes satisfactorily, and upon that point depended the success or failure in the production of those dyes.

Gen. WILLIAMS. While these developments were taking place there was in addition tremendous stimulus given to the erection of by-product coke ovens. After the start of the World War and prior to our entry therein, the purchase by the Allies of the by-products at very high prices furnished the incentive. After our entry the War Department, by special contracts, spurred on the development of this industry, which is also most important to the future of this country. A more detailed statement of this industry will be presented by another witness.

As a result of the activities outlined above, the nitrogen situation facing the War Department at the time of the armistice was, therefore, as follows:

(*a*) No. 1 plant was practically completed but had not proved a complete success, although indications were to the effect that further research would achieve satisfactory results.

(*b*) No. 2 plant was practically completed and its preliminary operation had indicated that it could be relied upon for successful production.

(*c*) The hydro electric dam at Muscle Shoals was in the course of construction.

(*d*) The requirements of the national defense act, namely, to develop methods of fixing nitrogen for military, fertilizer, and other uses and the development of the necessary power to accomplish this, were still incomplete and must be carried to completion by the War Department.

(*e*) In spite of the tremendous increase in by-product coke ovens we were still some 50 per cent dependent on importations for peace purposes alone and could only be assured of independence through the ability to construct and operate nitrogen fixation plants. We were therefore forced—until such a condition was brought about—to retain large stocks of sodium nitrate as a war reserve.

In order to make sure that the best interests of the general public for both peace and war were provided for with reference to the three holdings, amounting to some $100,000,000, the Secretary of War created a fixed-nitrogen administration, whose special duty was to study how to best meet the requirements of the national defense act and to best utilize or salvage with all reasonable assurance of nitrogen preparedness the Government holdings.

It at once became evident that in order to develop the No. 1 plant thorough research would have to be undertaken to determine the best method of overcoming the difficulties that had been encountered during its preliminary operation.

It also became evident that the art of nitrogen fixation was still in its infancy and was undeveloped, especially in America, and that a great deal of expensive research work must needs be done in order to lay firm foundations for our future in this respect. Not only the problem of fixation of nitrogen is involved, but there is also included the task of ascertaining the best form of this fixed nitrogen and combination of it with other materials to insure maximum advantage to the user or the farmer and manufacturer.

To solve this first phase of the problem a comprehensive research laboratory was organized and capable and experienced men were engaged to work out solutions to the problems. This problem will be treated more in detail by another witness.

It was also apparent that it would be of great benefit to the Government to ascertain as completely as possible the status of nitrogen fixation in foreign countries from both the producing and consuming standpoints. A commission was accordingly sent overseas to obtain the above from France, England, Germany, and Norway. They found a very active campaign in progress in all of these countries for the development of this work. A more detailed statement thereof will be presented by another witness.

It also became evident that the most logical use to which the No. 2 plant could be put was the fixing of nitrogen for fertilizers and other purposes in time of peace, but in such a way as not to destroy, but rather enhance its war-time value. Careful study was undertaken of just what products it would be best to manufacture at this plant, what the construction costs would be for converting it into a fertilizer plant, and what the production costs and probable sales value of the selected materials would be. The general results of these studies are set forth in Mr. Glasgow's letter of October 22, 1919, copies of which will be furnished, and which will be read. The more detailed phases of these studies can be given by other witnesses.

A study was also undertaken of the supply and demand of fixed nitrogen in the United States from the past, present, and future standpoints and this study quite definitely indicates that demand can only be met by the importation of tremendous quantities of nitrogen even in peace time, unless large quantities of nitrogen are made available through fixation processes. A more detailed statement will be submitted by another witness.

A study of the power situation that will be developed as a result of the construction of the Wilson Dam was also undertaken and this quickly showed that the most logical and practically the only use for this hydroelectric power will be for the operation of the No. 2 plant. The fixation plant needs the primary power of this river to operate it and on the other hand the hydroelectric station needs the fixation plant as an outlet for its power. A more detailed statement of the power situation will be presented by another witness.

As a result of all of the above studies there seemed to be no reasonable doubt but that the art of nitrogen fixation should be developed, that No. 1 plant should be made effective, that No. 2 plant should be operated, and that the Wilson Dam should be completed and its power made available for No. 2 plant.

The difficult question was to develop a means for accomplishing the above results in a satisfactory manner and at minimum cost to the United States. After thorough study it was felt that real nitrogen preparedness could only be accomplished at the present time by the Government itself, and it was recommended that all of the Government nitrogen fixation activities should be centered in a corporation that was able to operate through regular business methods in order to obtain the many and manifest advantages thereof. It was further recommended that the Government should make an appropriation of $12,500,000 to furnish the necessary capital to finance this corporation, the details of which amount are included in Mr. Glasgow's letter. To insure that the corporation conducted its affairs in a manner satisfactory to the Government it was also recommended that the directors of the corporation be appointed by the Secretary of War. All belongings of the corporation would, of course, belong to the Government. In furtherance of these recommendations the bill on which this hearing is being held was, therefore, prepared. The more detailed reasons why these plants should be operated and why this semi-Government-operation scheme is necessary will be covered by another witness.

The adoption of the recommended action will have a very important and economic effect upon our fixed nitrogen preparedness policy, and this will be covered in detail by another witness.

The CHAIRMAN (after consultation with members of the committee). The committee will now take a recess until 8 o'clock this evening.

(Thereupon, at 11.58 o'clock a. m., the committee took a recess until 8 o'clock this evening.)

EVENING SESSION.

The committee resumed its session at 8 o'clock p. m., pursuant to the taking of recess.

There was present with the committee, Maj. Gen. C. C. Williams, Chief of Ordnance, United States Army; Col. J. H. Burns, Nitrate Division, Ordnance Department, United States Army; Col. J. W. Joyes, Nitrate Division, Ordnance Department, United States Army; Dr. Alfred H. White, formerly lieutenant colonel, Nitrate Division, Ordnance Department, United States Army, professor of chemical engineering, University of Michigan; Maj. D. P. Gaillard, Nitrate Division, Ordnance Department, United States Army; Dr. A. B. Lamb, Chief Research Laboratory, Nitrate Division, Ordnance Department, United States Army; Mr. George J. Roberts, special assistant, Chief of Ordnance, Deputy Fixed Nitrogen Administrator; and others.

The CHAIRMAN. Mr. Roberts, who will you have next?

Mr. ROBERTS. Gen. Williams.

The CHAIRMAN. Gen. Williams, do you want to be heard again this evening?

Gen. WILLIAMS. No, sir; Col. Burns has the next subject to present in the matter, I think.

The CHAIRMAN. Col. Burns, we will be very glad to hear you.

STATEMENT OF COL. J. H. BURNS, NITRATE DIVISION, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Col. BURNS. Mr. Chairman, we are working under the assumption that you hope to complete these hearings this evening; is that correct?

The CHAIRMAN. Yes; that is correct.

Col. BURNS. And while we all have quite carefully prepared papers on the subjects we hoped to discuss, we have abbreviated them very much, to such an extent that we hope that we can present them in the time at your disposal this evening.

The CHAIRMAN. Let me ask you, Col. Burns; have you had hearings before the House committee on this same thing?

Col. BURNS. No, sir. So that what we would like to do is to make these statements to the committee at this time, and then put into the record the results of our completed studies, so that you will have the benefit of our complete studies on this subject.

The CHAIRMAN. That will be agreeable to the committee.

Senator SMITH of South Carolina. Col. Burns, what particular angle of this subject will you discuss?

Col. BURNS. It was my purpose now to give a general statement of the necessity for fixed nitrogen, and the sources thereof. We all know that the statement is constantly made that fixed nitrogen is indispensable for military and chemical and agricultural purposes, and I wanted to outline to the committee just how this substance has fitted into the scheme of things, and how it has helped to develop chemistry, and military science, and agriculture; and I have prepared quite a statement on that phase of the subject, but if the committee is willing to assume that part of my testimony, I will enter the statement in the record, and go on with other things that are of more interest to the committee now.

The CHAIRMAN. We will be very glad to have it; just hand it to the reporter.

(The statement submitted by Col. Burns is here printed in full as follows:)

GENERAL STATEMENT OF NECESSITY FOR NITRATES AND FIXED NITROGEN AND SOURCES THEREOF.

GENERAL.

The statement has been made that nitrates and fixed nitrogen are indispensable for strictly military purposes in the manufacture of powder and explosives, and for peace purposes in the manufacture of fertilizers and chemicals.

It is believed to be of interest and importance, in order that this indispensability may not be underestimated, to outline in a general way, how nitrates and fixed nitrogen have helped to develop and now fit into these various activities, and that will be the object of this statement. A general outline will also be given of the sources of these materials.

RELATION OF FIXED NITROGEN TO MILITARY PROGRAM.

The first chemical used in warfare seems to have been gunpowder—or a combination of potassium nitrate, sulphur, and charcoal. This use first occurred about 1250. It was revolutionary in its effect upon munitions. The bow and arrow, the spear, the sword, etc., were forced to give way to the various pistols, rifles, and guns that were invented to harness the tremendous power stored in this new substance. The chemical development was at first slow but gradually increased until to-day. The strength of an Army is not measured by its man power alone, but in great measure by its power to inflict damage through the intelligent and up-to-date use of chemical ordnance.

To-day the various branches of the Army, or the Infantry, the Artillery, the Cavalry, and the Air Service, all rely in great measure for their offensive power upon the tremendous force turned loose on the enemy by the detonation of the explosive charge contained in the shell or bomb or by the momentum of the bullet developed by the burning of smokeless powder. The Navy is similarly dependent. Her guns harness the power in the powder and transform it into momentum of the projectile, her submarine relies almost entirely upon the destructive force liberated by the detonation of the torpedo, and the defense against the submarine is based upon the explosive in the depth charge.

It is, therefore, apparent that powder, explosives, and chemicals are the heart of munitions, and it can be truthfully stated that fixed nitrogen is the heart of powder, explosives, and chemicals.

The slight affinity existing between nitrogen and the other elements gives a peculiar character to its compounds and many of them are extremely prone to decompostion with the almost instantaneous development of heat and gas. It is the application of this principle that has created the large explosives field that to-day exists.

Black powder is dependent for its explosive qualitive upon a nitrogen compound—or potassium nitrate.

Smokeless nitrocellulose powder is formed by the combination of a nitrogen compound with cellulose or purified cotton through the action of nitric and sulfuric acids.

T. N. T. or trinitrotoluol is similarly formed by the combination of a nitrogen compound with toluol; picric acid, explosive D, tetryl, ammonium nitrate, and all the rest are similarly dependent upon fixed nitrogen.

EARLY HISTORY OF THE DEVELOPMENT OF THE USE AND PRODUCTION OF NITROGEN.

The first nitrogen compound used in warfare seems to have been potassium nitrate. Records indicate that it was known in Europe about the eighth century. It took some 400 years, however, to learn how to combine it with sulphur and charcoal to form black powder.

For 600 years or from 1250 to 1875 black powder continued as practically the sole representative of chemistry in warfare and all efforts were toward its more efficient utilization. For many years it was used solely as a propellant and then sufficient knowledge was developed to utilize it in addition as an explosive-bursting charge in shells. The constant effort has always been to learn how to use more and more of it.

From 1875 to the present date, the development of powder and explosives has been very rapid. Knowledge for some time had been growing, and by this time was quite well advanced, which allowed of the nitrification, through the use of nitric acid, of various bases; namely, cotton, glycerin, mercury, carbolic acid, toluol, etc. This was a step of tremendous importance in explosives chemistry. The ability to use these nitrated materials in warfare has grown rapidly. In 1886, only 34 years ago, smokeless powder was invented and made applicable to the use of firearms, and it is since that time that T. N. T., ammonium nitrate, and other high explosives have been perfected and been combined with our munitions programs.

It is interesting to trace the quantities and sources of fixed nitrogen available during this development. Practically the only natural deposits of potassium nitrate in existence occur in British India and from early history to the present day these deposits have been in great measure the source of nitrogen for black powder. During the various wars that have occurred from the invention of black powder to the present day there has apparently always been a shortage of nitrogen on one side or the other, and all sorts of schemes have been tried in an effort to overcome this shortage. It so happens that animal liquid contains considerable nitrogen in the form of ammonia. Wood ashes also contain potassium. In the presence of limestone these two materials gradually combine and form potassium nitrate. In application of this principle, "nitrate farms" have for several hundred years been relied upon, especially in time of war to fix the ammonia in animal fluids in a satisfactory form for munitions purposes. History states that in Sweden every landowner was obliged to furnish to the Government each year a certain quantity of homemade saltpeter, and all sorts of animal refuse used up in special "saltpeter plantations," and about 100 tons per year were obtained. In France, during the wars of the Revolution, when British nitrate from India was unobtainable, the process was made compulsory by a decree of the convention and history states that some 2,000 tons per annum were obtained in this way. In our own country, during the Civil War, the South had to rely in great measure upon similar farms for the production of its nitrates.

During the Crimean War, when Russia was prohibited from obtaining nitrate from India, due to Great Britain's participation therein, a process was developed of making potassium nitrate from sodium nitrate, and this has assured a reasonable supply to the world, even though Indian nitrate is unobtainable.

REQUIREMENTS OF NITROGEN FOR STRICTLY MILITARY PURPOSES.

With the development of the nitrification of cellulose, toluol, glycerin, etc., and their tremendous consumption in shell, mines, bombs, etc., the demand for suitable fixed nitrogen compounds for war purposes has very materially increased.

We have already seen how Sweden by its farms was able to produce only some one hundred tons of nitrate per year, which would equal about 14 tons of nitrogen.

In the Napoleonic wars, France produced 2,000 tons of nitrate per year, equal to 280 tons of nitrogen or over 20 times Sweden's consumption. With the man power, armament, and rate of fire in effect at the time of the armistice, one division required for its powder and explosives approximately 3,000 tons of fixed nitrogen per year, or over 10 times the amount used by the entire French army per year during the French revolutionary period.

A study of Mr. Crowell's America's Munitions shows quite conclusively how extremely large has been the increase in the rate of fire of ammunition and in the total consumption thereof. It shows that during one month of 1918 (which was the average of the year 1918) the French and British consumed over two and one-half times the number of rounds of artillery ammunition that were consumed by the Union forces during the entire Civil War. This would in general correspond to a ratio of 120 to 1. And due to the increased use of explosives the proportionate consumption of nitrogen is still greater.

During the year 1918 we were consuming inorganic nitrogen in the United States at the rate of some 420,000 tons, and of this over 60 per cent was for strictly military purposes and over 75 per cent was imported in the form of sodium nitrate from faraway Chile.

It is, of course, difficult to forecast what our requirements for nitrogen for strictly military purposes will be as they will in great measure depend upon the enemy or combinations of enemies that we are called upon to fight. But based upon the experiences of the past there is every reason to believe that future requirements in a major war effort will be materially greater than the already gigantic demand.

REQUIREMENTS OF NITROGEN FOR INDUSTRIAL PURPOSES.

The demand for fixed nitrogen for peace pursuits can be divided into two main classes—fertilizers, and the chemical industry.

Nitrogen for fertilizers.—The three essential elements of a complete plant food are fixed nitrogen, phosphoric acid, and potassium. And of these three nitrogen is claimed to be the most important and it is the most expensive.

Fertilizer has, of course, since the earliest days of human history, been used in the growing of plants. In the first instance, it consisted in placing back on the farm the droppings of animals as well as the remains of the crops. As chemical development has progressed, however, study has been made of just what elements are needed and in what form they should be used to properly sustain and develop plant life. And as a result of this, knowledge has been gained as to the inorganic or mineral materials that can be used to augment as fertilizers the organic substances previously used. And one such substance is fixed nitrogen in one form or another.

Food must, of course, be raised in war time as well as in peace time for the population of the country is substantially the same. But due to the decrease in farm hands through their enrollment in the Army and through their employment in munitions and war plants of various kinds, it is manifestly extremely difficult to work as many acres. In time of war, it is, therefore, necessary to raise more crops per acre per man, than at any other time, and the only way this can be accomplished is through the more abundant use of fertilizer.

Aside from this increased demand during war time it must be remembered that the present civilization is demanding more from the farms. A constantly increasing percentage of our population is living in cities and purchasing their food stuffs rather than raising them. In addition, the natural deposits of plant food in our soils are constantly decreasing. The result is that more and more fertilizer must constantly be used in the form of inorganic materials and especially fixed nitrogen.

The first use of inorganic manures occurred about 1850 as a result of German research development and it was some 25 or 30 years later that the use was taken up in the United States. It has, of course, very rapidly expanded until to-day some 8,000,000 tons are used per year having a value of approximately $400,000,000. Of this amount some 100,000 tons are fixed nitrogen with a value of approximately $40,000,000.

Nitrogen for the chemical industry.—Nitrogen is vital to that part of chemical industry consisting essentially of domestic explosives, refrigeration, the manufacture of dyes, artificial leather, photographic films, celluloid, and other products of nitrated cotton.

We all know of the field of domestic explosives—how they are being used in constantly increasing amounts to mine metal ores, coal, rock, etc., to displace human labor in the excavation of ditches and foundations, the planting and cutting of trees, etc., and we know how important it is that this use be not only maintained but increased in time of war.

The principal material used in refrigeration is ammonia. Refrigeration is constantly increasing during peace and in time of war it jumps very rapidly.

The manufacture of dyes, artificial leather, photographic films, celluloid and other products of nitrated cotton is very much an infant industry in the United States. It is, however, rapidly growing. Some parts of it could be dispensed with in time of war, but many could not.

It should be remembered that this entire field is a product of the development of knowledge which allows us to nitrate certain bases by the use of nitric acid, and this knowledge was really only started some 40 years ago. Its growth was at first slow, but in later years, the progress has been more rapid until to-day about 100,000 tons of fixed nitrogen are consumed per annum.

As a general statement of the rate of growth of the use of inorganic nitrogen it seems to be the experience of the world that it doubles every 10 years.

SOURCES OF NITROGEN.

To meet the demand already outlined we have been dependent upon domestic inorganic nitrogen in the form of ammonia and ammonium sulphate from by-product coke ovens and gas works; domestic organic nitrogen in the form of dried blood, tankage, dried fish scrap, and especially cottonseed meal; and upon imported inorganic nitrogen in form of nitrate of soda from Chile, of by-product coke oven ammonium sulphate from Europe, and of imported synthetic nitrates.

NITROGEN FROM BY-PRODUCT COKE OVENS AND GAS WORKS.

At present this is the only source of inorganic nitrogen in the United States. By-product coke ovens are most important to the future of America and it is thought that a brief explanation should be given. Coke is, of course, produced from bituminous coal by driving off from the latter all of the volatiles and retaining only the carbon and ash. The coking of coal is an old industry and was developed with the iron industry, coke being necessary in the blast furnace to reduce iron ores and form pig iron. In the early days coal was coked in so-called beehive ovens in which the coal was heated sufficiently by the burning of a portion of it to drive off the volatiles. These volatiles amounting to approximately 28 per cent of the weight of the coal are, however, extremely valuable and in recent years steps have been taken to capture them through the use of by-product coke ovens. As compared with the production of approximately 0.65 ton of coke from a ton of coal by the beehive process—a by-product oven will produce approximately 0.72 ton of coke (or 10 per cent more) and in addition some 4 pounds of fixed nitrogen in the form of ammonia, 10 gallons of tar, 5,000 cubic feet of gas, and 2¾ gallons of light oil or motor spirit. All of these are valuable and in general terms the value of the products from this oven is about 50 per cent greater than from the beehive oven The light oils can be used as motor spirit in time of peace and furnish toluol and benzol for the manufacture of explosives in time of war.

By-product ovens were developed by the Germans and were first introduced into America in 1893. From this time until 1914, when the World War started, development was such that only approximately 25 per cent of the total coke used in the United States was coked therein. Since then the increase has been abnormal. Growth was developed during 1915 and 1916 by the purchase by the Allies of the by-products at excessive prices. In 1917 and 1918 the Ordnance Department in order to obtain increased supplies of toluol further spurred on the construction of by-product ovens by special contracts. As a result of these efforts the country is at present coking in by-product ovens some 56 per cent of all of its coke.

It would be ideal from a conservation standpoint and from a military standpoint if all the coke could be produced in such ovens, but there are various reasons against it and it is probable that not over 70 per cent of our coke can on the average be so produced. Coke production must keep pace with the steel industry with which its future is inseparably combined. The construction of such ovens in excess of demands for their main product—coke—and simply to obtain such valuable military by-products as nitrogen and toluol, could only be justified as an extreme war measure as the initial cost is very high, the time of construction long, and the salvage value for other purposes negligible.

To day the United States is getting less than half its peace-time inorganic nitrogen requirements from coke ovens, and as every reasonable indication is to the effect that the demand for such nitrogen will grow faster than its production from by-product ovens it is obvious that other sources must be always available to keep supply and demand in step.

Nitrogen is produced in gas works from coal in a manner similar to the by-product oven. The quantity is relatively small.

DOMESTIC ORGANIC NITROGEN.

Domestic organic nitrogen in the form of dried blood, tankage, dried fish scrap, and cottonseed meal are the products of the slaughterhouses, the fisheries, and the cottonseed mills of the South. Several years ago very large quantities of these materials were used in mixed fertilizers to supply the nitrogen. Practically all of them can, however, be used as food for stock and this use has been so much developed that the amount available for fertilizer is becoming decreasingly smaller and at a very rapid rate. In a few years it is quite probable that their use as such will practically have entirely disappeared and the nitrogen will have to be replaced by inorganic nitrogen.

NITRATE OF SODA FROM CHILE.

The rainless deserts of northern Chile contain a vast supply of raw material called "caliche," from which the commercial salt known as nitrate of soda or Chile saltpeter is refined. Various estimates exist as to the extent and consequent life of these deposits. Production during the last five years has been at the rate of between 2,500,000 and 3,000,000 tons annually. At this production rate the known supply will be sufficient for between 40 to 70 years. However, the explorations upon which these figures are based have not been as thorough or extensive as might be, and it is possible that the existing reserves are considerably greater. It is constantly becoming more and more difficult, however, to obtain the material. In 1901 the average nitrate content of the caliche refined amounted to 28 per cent; in 1909 it amounted to only 19 per cent. In 1881 the quantity of nitrate produced by an individual laborer was 73 tons per year, while in 1911 it had fallen to 56 tons.

This supply of material has been of tremendous importance in the development of the chemical, as well as of the fertilizer industry. The present era of explosives, dyes, artificial leather, etc., is dependent upon the reaction between some base and nitric acid. And practically all of the nitric acid manufactured up to the World War, and all of it used in that war, except by Germany, was made from Chilean sodium nitrate. And even to-day entire dependence, except by Germany, is had on this material for the manufacture of nitric acid. We are at present able, however, to manufacture nitric acid from ammonia, although at increased cost, and our absolute dependence upon sodium nitrate is thus stopped. It is also possible to produce sodium nitrate from domestic nitrogen.

Again, sodium nitrate was practically the first inorganic nitrogen compound used in fertilizer, and to-day is very largely used for this purpose.

During the World War the United States was absolutely dependent upon imported Chilean nitrate to supply over 75 per cent of its inorganic nitrogen demand, and imported during 1918 some 2,000,000 tons of nitrate, or two-thirds of the entire Chilean production.

BY-PRODUCT COKE-OVEN SULPHATE OF AMMONIUM FROM EUROPE.

Prior to the war fairly large quantities of this material were imported from England, as that country was not apparently able to utilize all of its product. The war, however, forced her to grow more crops rather than to import them, and her only salvation was to use more fertilizer as well as till more land. As a consequence, exportation stopped, and it seems probable that economic conditions will force her in the future to be as self-sustaining as possible.

IMPORTED SYNTHETIC NITRATES.

The European countries have apparently been more alive to the nitrogen problem than the United States. They have erected plants and produced fixed-nitrogen materials in such quantity that some could be exported, especially from Norway and Canada. The amount imported into the United States has not been very large, but it is and will probably continue to be in constantly increasing amounts.

FIXATION OF ATMOSPHERIC NITROGEN.

Chemists have long recognized the atmosphere, of which four-fifths is nitrogen, as the huge reservoir that must ultimately be relied upon to supply our needs in the way of nitrates or other fixed-nitrogen compounds. The very aloofness of nitrogen or its refusal to combine or stay combined with other elements which gives it so much value in explosives, on the other hand causes tremendous difficulty relatively in harnessing it. The artificial fixation of atmospheric nitrogen by chemical or electrochemical means has, however, been developed in recent years, and several methods are in actual operation.

In all cases it is necessary to force the combination of nitrogen with some other material. This combined nitrogen can then be manipulated chemically so as to produce the desired material.

Col. **Burns**. With the committee's permission, we would like to call Col. White, who will give a general statement with reference to the fixing of nitrogen throughout the world.

Senator **Smith** of South Carolina. You mean by this process the cyanamid process?

Col. **Burns**. Yes; the various processes that exist; not only the cyanamid process but the numerous other ones.

STATEMENT OF DR. ALFRED H. WHITE, FORMERLY LIEUTENANT COLONEL, ORDNANCE DEPARTMENT, UNITED STATES ARMY, PROFESSOR OF CHEMICAL ENGINEERING, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

Dr. WHITE. The subject that I am to present to you gentlemen is with reference to the general methods of the fixation of nitrogen, and I have prepared a paper on the subject, and with your permission I will submit this to the record.

The CHAIRMAN. We will be very glad to have it.

(The statement submitted by Dr. White is here printed in full, as follows:)

GENERAL STATEMENT OF METHODS OF FIXING NITROGEN AND STATUS OF PROJECTS THROUGHOUT THE WORLD.

The last 20 years has seen great experimental activity in the field of nitrogen fixation. It grew to a feverish height in the principal combatant countries during the war. The end of the war sees two processes developed and in active operation and a host of other processes which have failed or are economically possible only under peculiar local conditions or are still undeveloped. New processes may develop in a way which will make them superior to those which are now accepted, but none of them have shown the promise which warrants present consideration. The arc process is one of those which requires such tremendous quantities of cheap power that it is only feasible commercially in remote districts where water power is useful for no other purpose. Even the stress of war has failed to develop it materially. The two processes which have attained commercial importance are the cyanamid process and the process of direct synthesis of ammonia, with which the names of Haber and Bosch are usually associated.

SYNTHETIC AMMONIA PROCESS.

The synthetic ammonia process owes its laboratory development to the studies of Haber and its first commercial development to the engineers of the Badische Anilin und Soda Fabrik, with Bosch and Mittasch as the principal engineers. The first successful factory operation was attained in 1913. This process is relatively simple in theory, but its operation is complicated and difficult. It taxes the resources of German ingenuity, supported by the pressing demands of the Government for four years to develop this process to an approximation of success in 1913. Germany was forced to rely on it and devoted tremendous energy to it during the war, because Germany does not possess water power and could not develop electrical power necessary to fix sufficient nitrogen for her armies by the cyanamid process. It was a matter of life or death to Germany to build these plants and to operate them successfully.

The process may be outlined as follows: In its simplest and most attractive form, the process may be stated as involving the combination of pure nitrogen and pure hydrogen to form ammonia. The difficulties are first, the preparation of pure hydrogen and second, the realization of the combination between nitrogen and hydrogen.

The only source of pure hydrogen which has been attempted commercially for this purpose is the hydrogen present in steam. Steam is blown into a gas producer in a manner similar to that employed in making water gas commercially, and a gas with about 50 per cent hydrogen is obtained. The balance of this gas is mainly carbon monoxide. This must now be converted into hydrogen through reaction with more steam at a temperature approaching a red heat and in presence of a catalyst whereby the hydrogen of the steam is set free and the carbon monoxide converted to dioxide, also an impurity. This process requires the addition of heat and the use of a very large excess of steam, so that it is a distinctly expensive process. The next step in the operation is the removal of the carbon dioxide. The gases are first cooled, then compressed to a pressure which in practice may run as high as 1,400 pounds per square inch, and then passed through water scrubbers which remove most of the carbon dioxide and also about 10 per cent of the valuable hydrogen.

Further purification of the gas must now be made by scrubbing with caustic solution and with copper salts before it is ready for the initial step of the apparently simple operation of ammonia synthesis.

The difficulty in the synthesis of ammonia comes from the repugnance of nitrogen and hydrogen to unite. It is only under pressures of 1,400 to 2,800 pounds to the square inch at a temperature approaching red heat and through the assistance of a catalyst exceptionally difficult to prepare and sensitive to the action of poisons, that success has been attained. As it stands in commercial practice, the gas issuing from the conversion chamber carries only about 5 per cent of ammonia gas. This must be removed by refrigeration or by scrubbing with water, both operations still being continued under high pressure, and the gases must then be recirculated back into the system.

It is not too much to say that this is the most difficult chemical engineering process which has ever been successfully accomplished. It involved a long train of apparatus for handling combustible gas under pressures of 1,500 to 2,800 pounds per square inch. The gases must be subjected to delicate and thorough purification processes. There is no possibility of providing storage for these compressed gases and an accident to any part of the system results in a stoppage of the whole process. The purified gases must be heated to practically a red heat, and ordinary steel is made brittle by this treatment, so that disastrous explosions have resulted. As a final result we have ammonia either in the form of anhydrous ammonia or as aqua ammonia.

This ammonia must now be converted into a substance useful for munitions or as a fertilizer.

CYANAMID PROCESS.

The cyanamid process was developed about 20 years ago in Germany and has been ably handled by a syndicate which granted licenses to an affiliated group of companies throughout most of the civilized nations of the world. Before the war there were plants in Germany, Italy, France, Switzerland, Austria, Norway, Sweden, Japan, and Canada. The interchange of information between these affiliated companies with their skilled technical staffs and their experience of 10 years of operation before the outbreak of the war had brought this process to a high degree of operating excellence, so that its performance was standard and its reliability was unquestioned. Many new factories were built to operate by this process during the war, both in Germany and in France.

The process consists of a number of stages, each of which has been thoroughly worked out. The installation of a plant does not require apparatus which is not readily obtainable in any civilized industrial nation, but does require an amount of electrical energy which makes it commercially impracticable to locate a plant at any point where large amounts of electrical power are not continuously available at such low price as to make it almost necessary to have a hydro-electric installation.

The process starts with lime and coke, which are mixed and fused in an electric furnace to form calcium carbide in the same way that carbide is manufactured as a principal product for the production of acetylene. The second stage consists in grinding this carbide and treating it with pure nitrogen gas at a red heat. The nitrogen gas is obtained by liquefaction of air according to the well-known Linde or Claude processes and with only slight modifications of the standard apparatus which is used to produce compressed oxygen at so many stations throughout the United States. The union of the nitrogen with the calcium carbide forms the product commercially called lime nitrogen, which carries about 20 per cent of fixed nitrogen.

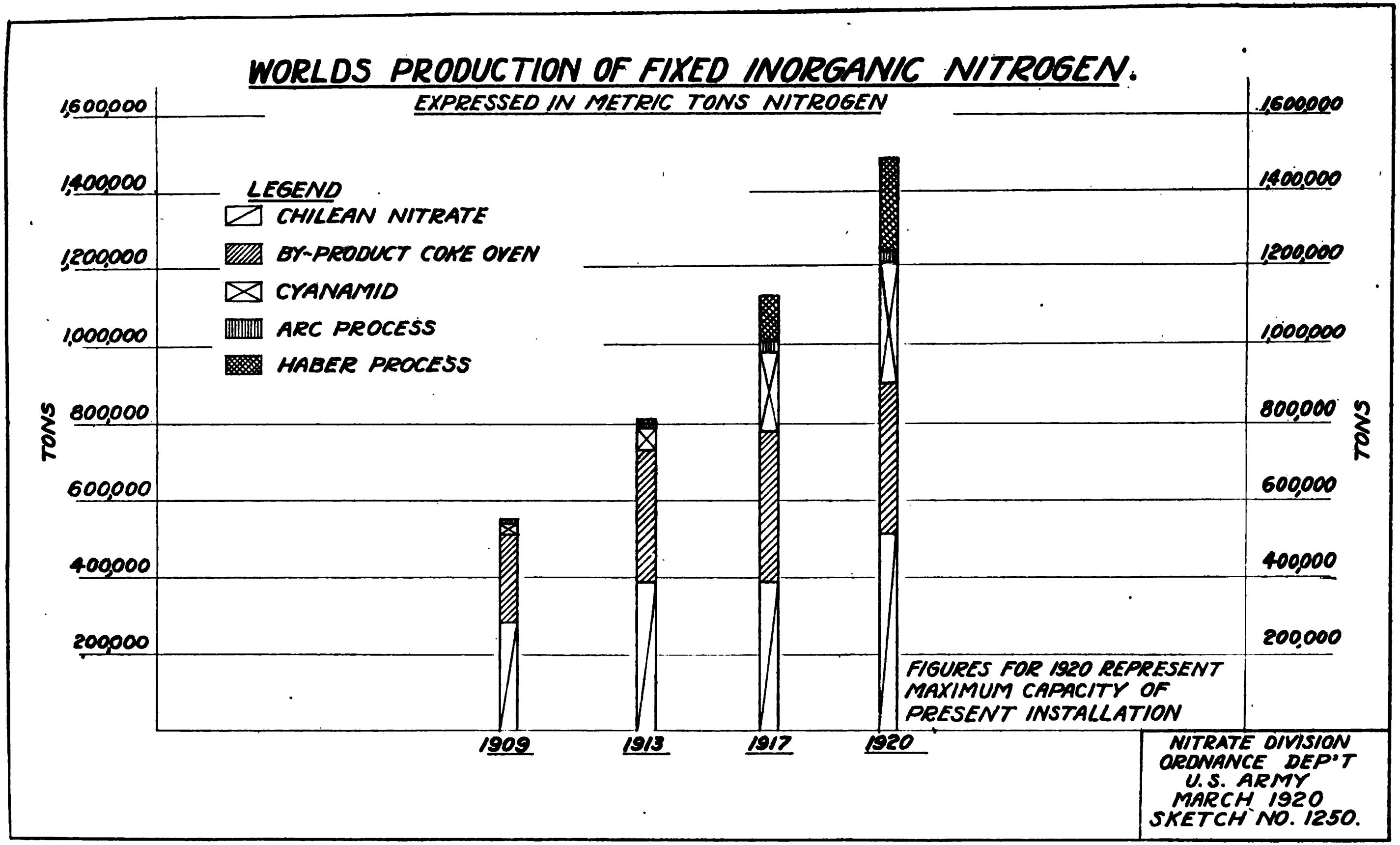
This lime nitrogen may be used directly as fertilizer, after a simple treatment with a small amount of water to hydrate the free lime and remove impurities.

If it is desired to convert it into ammonia, the ground lime nitrogen is fed into a digester and treated with dilute alkali and steam under pressure of about 150 pounds to the square inch. The nitrogen is converted almost quantitatively into ammonia, which is evolved as a gas and may be absorbed in sulphuric acid to make ammonium sulphate to be used for fertilizer, or it may be sold in other forms.

The ammonia from either process may be easily converted into sulphate for fertilizer. The cyanamid process has the advantage that it also yields, as its initial product, cyanamid which is available directly as a fertilizer.

MANUFACTURE OF NITRIC ACID AND AMMONIUM NITRATE FROM AMMONIA.

Both the direct synthetic and the cyanamid processes yield ammonia. If it is desired to use this ammonia for munition purposes, it is oxidized with air at a rather dull-red heat in converters containing special materials to promote the oxidation of the ammonia to oxides of nitrogen. Platinum is the best known of the catalytic materials used, but various oxides of more common metals have been used with success. The efficiency of the conversion is well over 90 per cent. The gases from these converters are cooled and passed up through towers of acid-proof masonry, down which



WORLDS PRODUCTION OF FIXED INORGANIC NITROGEN.

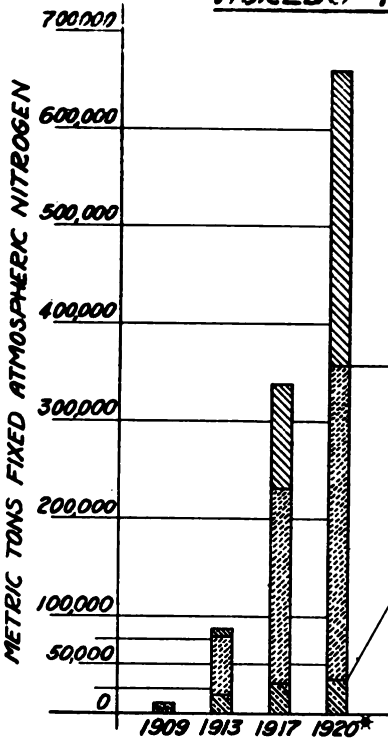
EXPRESSED IN METRIC TONS NITROGEN

FIGURES FOR 1920 REPRESENT MAXIMUM CAPACITY OF PRESENT INSTALLATION

NITRATE DIVISION
ORDNANCE DEP'T
U.S. ARMY
MARCH 1920
SKETCH NO. 1250.

PLATE 2.

WORLDS PRODUCTION OF FIXED ATMOSPHERIC NITROGEN.



DATA FOR 1920 ESTIMATED MAXIMUM CAPACITY		
COUNTRY	NUMBER OF PLANTS	MAXIMUM CAPACITY METRIC TONS NITRON
GERMANY	2	300,000
UNITED STATES	1	8,000
TOTAL	3	308,000
GERMANY	7	120,000
AUSTRIA	2	22,000
FRANCE	9	58,000
NORWAY-SWEDEN	3	28,000
ITALY	5	18,000
SWITZERLAND	3	7,000
CANADA	1	12,000
JAPAN	4	20,000
UNITED STATES	1	40,000
TOTAL	35	325,000
FRANCE	2	1,300
NORWAY-SWEDEN	2	30,000
ITALY	2	1,200
CANADA	1	800
UNITED STATES	1	300
TOTAL	8	33,600

PROCESS	METRIC TONS OF NITROGEN			
	1909	1913	1917	1920*
▨ ARC & MISC.	3,000	18,000	30,000	33,600
▒ CYANAMID	2,500	60,000	200,000	325,000
▨ HABER	0	7,000	110,000	308,000
TOTAL	5,500	85,000	340,000	666,600

* ESTIMATED MAXIMUM CAPACITY

NITRATE DIVISION
ORDNANCE DEP'T
U. S. ARMY
MARCH 1920.
SKETCH NO. 1249

water trickles, and are converted into nitric acid of about 40 to 50 per cent concentration. This nitric acid may then be concentrated to produce the strong acid required for the manufacture of smokeless powder, T. N. T., or other explosives, or it may be neutralized with a portion of the ammonia which did not pass through the oxidizers to produce the ammonium nitrate usable as a high explosive or as a fertilizer.

TABLE I.—*World's production of fixed inorganic nitrogen.*

[Expressed in metric tons of nitrogen.]

	1909	1913	1917	1920
Chilean nitrate	300,000	390,000	392,000	500,000
By-product ammonia	212,000	343,000	364,000	410,000
Atmospheric nitrogen:				
Cyanamid process	2,500	60,000	200,000	325,000
Arc and miscellaneous process	3,000	18,000	30,000	32,500
Haber process		7,000	110,000	308,000
Total	517,500	818,000	1,096,000	1,575,000

STATISTICS OF NITROGEN FIXATION.

Statistics of the sources and total quantities of inorganic fixed nitrogen are at best unreliable, and it is admitted that the following figures may be in error. They have, however, been compiled from the most reliable sources and are not believed to err in their broad outlines. No account is taken in these figures of organic nitrogen such as is found in blood, tankage, etc., for however important this may be for agriculture, it is not available for manufactures or munitions.

The world's production of fixed inorganic nitrogen is given in Table I and is shown graphically in Plate 1, where the first three columns give the actual production of fixed inorganic nitrogen for the years 1909, 1913, and 1917. The column for 1920 gives, not the actual, but the maximum production believed to be possible if all countries utilized all their resources to the limit. The actual production will necessarily be lower than this.

The supply from Chile was relatively constant in 1913 and 1917, and the figure of 500,000 tons of nitrogen given as the possible production for 1920 corresponding, roughly, to 3,000,000 tons of Chilean nitrate is believed to be as much, if not more than Chile will ever produce. The world's supply from by-product coke ovens was also greatly stimulated by new construction during the war, and a lull in further new construction may be expected. The totals for 1920 are large, but it must be remembered that they represent maximum output and will not be reached. Attention should also be called to the great increase in the demand during peace times, as shown by the growth between 1909 and 1913. Some of the students who have studied the situation claim that the increases due to war, large though they are, are little more than would have been called for in peace times.

GROWTH OF FIXATION OF ATMOSPHERIC NITROGEN.

The growth of fixation of atmospheric nitrogen is indicated in Plate 1, but is shown more in detail in Plate 2, where the increase by periods is charted.

The figures may be summarized as follows:

TABLE II.—*World's production of atmospheric fixed nitrogen.*

[In metric tons of nitrogen.]

Process.	1909	1913	1917	1920[a]
Arc and miscellaneous	3,000	18,000	30,000	33,600
Cyanamid	2,500	60,000	200,000	325,000
Haber		7,000	110,000	308,000
Total	5,500	85,000	340,000	666,600

[a] Estimated maximum possible production.

Details of the world's present installations and their present maximum capacity are given in Table III.

TABLE III.

Country.	Number of plants.	Process.	Estimated maximum capacity, metric tons nitrogen.
Germany	2	Haber	300,000
United States	1	do	8,000
Total	3		308,000
Germany	7	Cyanamid	120,000
Austria	2	do	22,000
France	9	do	58,000
Norway and Sweden	3	do	28,000
Italy	5	do	18,000
Switzerland	3	do	7,000
Canada	1	do	12,000
Japan	4	do	20,000
United States	1	do	40,000
Total	35		325,000
France	2	Arc and miscellaneous	1,300
Norway and Sweden	2	do	30,000
Italy	2	do	1,200
Canada	1	do	800
United States	1	do	300
Total	8		33,600

It will be clearly seen that the arc process is entirely minor, that the main reliance of all nations except Germany is cyanamid and that Germany has succeeded in developing the Haber process into a gigantic industry able to function successfully as a war measure.

INTERNAL RESOURCES OF FIXED INORGANIC NITROGEN.

The measure of a country's independence in war time is its domestic supply of fixed inorganic nitrogen. Its importance was recognized by our revolutionary ancestors, for the Congress in session in Philadelphia on July 28, 1775, passed a resolution issued as a proclamation over the signature of John Hancock with a preamble commencing—

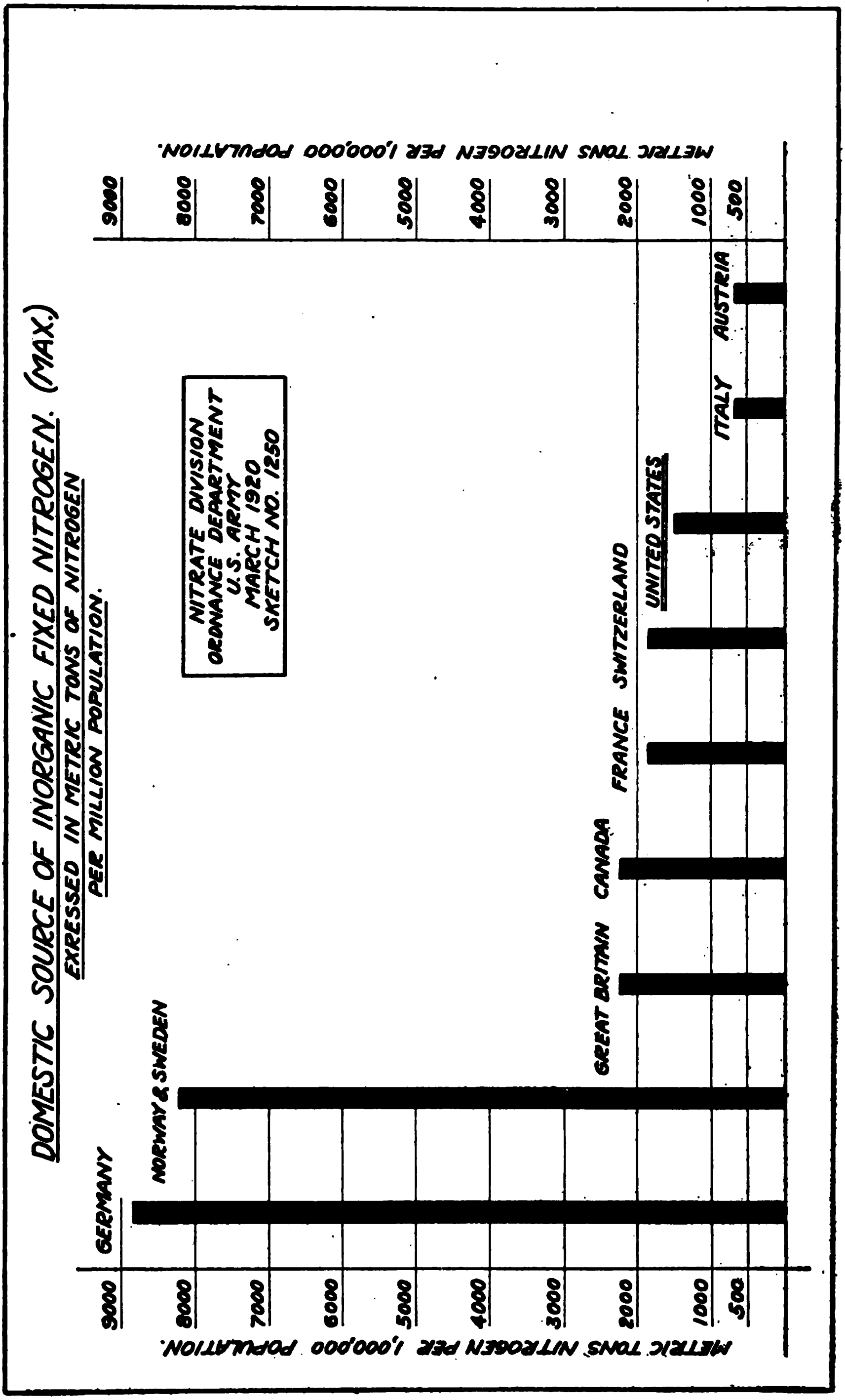
"Whereas the safety and freedom of every community depends greatly upon having the means of defense in its own power, so that the United Colonies may neither during the continuance of their present important contest for Liberty, nor in any future time be under the expensive, uncertain, and dangerous necessity of relying on foreign importations for gun powder * * *."

Money was scarce in the Colonies, but the Congress followed this preamble with a recommendation to the various assemblies to buy all the merchantable saltpeter that might be recovered until October 1, 1776, at one half dollar a pound.

Lack of nitrate nearly cost this country the War of 1812, and the urgent need and the steps taken to promote nitrogen fixation in the recent war are still matters fresh in our memory. Where do we stand after all our expenditure? Are we well up on the list of nations?

There are two domestic sources of fixed inorganic nitrogen—by-product coke ovens and atmospheric nitrogen. The maximum resources of the leading nations are given in Table IV. The last column gives the resources per million of prewar population. This is really the measure of a country's ability to defend itself.

PLATE 8.



DOMESTIC SOURCE OF INORGANIC FIXED NITROGEN. (MAX.)

EXPRESSED IN METRIC TONS OF NITROGEN PER MILLION POPULATION.

NITRATE DIVISION
ORDNANCE DEPARTMENT
U.S. ARMY
MARCH 1920
SKETCH NO. 1250

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TABLE IV.—*Domestic sources of inorganic fixed nitrogen (maximum) in 1920.*

[Expressed in metric tons of nitrogen.]

Country.	Population from atlas.	By-products from coal.	Atmospheric nitrogen.			Total.	Tons nitrogen per million population.
			Arc.	Cyanamid.	Haber.		
Germany	65,000,000	150,000	....	300,000	300,000	570,000	8,760
Norway and Sweden	8,000,000	....	30,000	28,000	....	58,000	7,250
Great Britain	45,000,000	100,000	....	....	....	100,000	2,240
Canada	7,200,000	3,000	800	12,000	....	15,800	2,200
France	40,000,000	15,000	1,300	58,000	....	74,300	1,850
Switzerland	3,800,000	....	....	7,000	....	7,000	1,840
United States	103,500,000	105,000	300	40,000	8,000	153,300	1,480
Austria	51,000,000	10,000	....	22,000	....	32,000	630
Italy	35,000,000	3,000	1,200	18,000	....	22,200	630
Other countries	....	27,000	....	20,000	....	47,000	....
Total	....	413,000	33,600	325,000	308,000	1,079,600	....

These figures are also shown graphically in Plate 3, from which it will be seen that the United States, even after all its war development, is not equal to any of the larger European nations, and indeed is the most defenseless of all the countries, with the exception of Austria and Italy. Switzerland and France are materially better off than we are. Great Britain who has officially recognized the extreme gravity of her position has a 50 per cent greater domestic supply of fixed nitrogen than this country possesses Germany and Norway and Sweden are so far above the rest as to be beyond comparison

FUTURE DEVELOPMENT OF NITROGEN FIXATION IN THE UNITED STATES.

These figures are surely sufficient to show the necessity for promoting the fixed nitrogen industry of this country. Which of the processes should be developed?

There are only two plants of measurable size in this country, both owned absolutely by the Government. Each represents one of the approved types, the cyanamid and the Haber. What are the merits of the two?

The cyanamid process is made up of relatively simple steps. It has the disadvantage of requiring a large amount of electrical power and its commercial development has been restricted on that account.

It has, however, been developed in many installations. and the Government has in its nitrate plant No. 2 what is probably the most efficient example of the process. It is located at the source of cheap power, which overcomes the disability mentioned above. The cost of manufacture has been proved by definite tests.

The direct synthetic ammonia or Haber process is represented by three plants in the world—two in Germany and one in the United States. Nitrate plant No. 1 is owned absolutely by our Government, and the German plants are to a considerable extent owned and controlled by the Government.

The direct synthetic ammonia process is an extraordinarily difficult chemical and mechanical engineering operation, which so far has been carried to success only at the two affiliated German plants and nowhere else in the world. It must operate like a watch, or it does not operate at all. Possibilities of very cheap production have been held out by advocates of this process, but it is the opinion of those who have seen the German plants that there is no hope of operation of the process in this country for a cost of less than 10 cents per pound of ammonia (NH_3), even where the items of amortization or interest are excluded.

Claims have recently been made that by a union of the Haber and the Solvay, or ammonia-soda process, for manufacture of soda ash, great economies may be expected. The manufacture of soda ash is itself a highly complicated engineering operation. Before its operators allow it to be rigidly linked with another delicate and difficult chemical engineering process, they will demand operating certainty in the new process. This is far from attained. Further the union of the two processes presents many technical difficulties, not the least of which are connected with the recovery of ammonia as ammonium chloride and its disposition as a fertilizer. The recovery of ammonium chloride offers technical uncertainties, the product tends to cake in storage, and its value as a fertilizer has been questioned. Many field experiments will have to be made before its scope of usefulness is proven and the effect of its long-continued application to the soil is a question not yet answerable.

The answer to the question as to which process should be developed may be answered by the single word—both. The Government owns a plant for each process. They are located so close together that one organization can handle them. The cyanamid plant is of proven excellence; it can operate at a profit, and should not be allowed to deteriorate by idleness. The synthetic ammonia plant should be developed as a factor of safety in time of war and as a pilot plant for our manufacturers in in time of peace.

The figures presented show that the world is possibly overproduced in fixed nitrogen. The field is not an attractive one for private capital, for Germany with her plants already largely amortized and under Government control will attempt to dominate the world and prevent future development. Chile will struggle to maintain her export trade. The position of the by-product coke ovens already built is secure, but what individuals will risk their money in developing nitrogen fixation with the German Government as a direct opponent, and the Chilean Government with a vital interest and a strong weapon to use against it? The field of fixation of atmospheric nitrogen is clearly one for Government operation if there ever was one.

The CHAIRMAN. Just one question: In what countries is the Haber process used outside of Germany?

Dr. WHITE. None, except our plant No. 1 at Muscle Shoals, and that was hardly used. No other country, except Germany, has developed that. The Haber process is probably the most difficult engineering process that has ever been attempted.

Senator SMITH of South Carolina. The Haber process?

Dr. WHITE. Yes.

The CHAIRMAN. The processes you use are all patented processes owned by the American Cyanamid Co.?

Dr. WHITE. This process is the General Chemical Co.'s process. Some of the processes which they used were patented, and some were so old in the art that they were not patentable.

The CHAIRMAN. Do you know whether the German Government, when they had a Government, owned their own patents, or if they were controlled by private enterprise?

Dr. WHITE. Col. Joyes can give you better information on that subject than I can. This process was put out by Badische Anilin und Soda Fabrik, but I am sure that the Government was considerably interested in the development of it. I am not sure that it has ever come out what the original development was, but we do know that now the whole nitrogen industry is controlled by the German Government.

The CHAIRMAN. Can you tell the committee what the cost is per ton to the Government for these patents? In other words, what is the royalty that you are paying to these people that now own the patents?

Dr. WHITE. The contract with the General Chemical Co. provided for a royalty of $5 a ton. I think Mr. Roberts could answer that question better.

Mr. ROBERTS. The Haber process is $5 a ton.

Dr. WHITE. That is, $5 a ton of fixed nitrogen used for fertilizer. That, of course, is only if we use the General Chemical Co.'s process; if the General Chemical Co.'s process is not used, we would not pay them any royalty.

The CHAIRMAN. Is that the same company Mr. Washburn is interested in?

Dr. WHITE. No, sir; that is the other company.

Senator SMITH of South Carolina. You said $5 a ton for the nitrogen?

Dr. WHITE. Yes, sir.

Senator SMITH of South Carolina. That was not in the form of fertilizer?

Dr. WHITE. Yes, sir.

Senator SMITH of South Carolina. Pure nitrogen per ton?

Dr. WHITE. Yes, sir.

Senator SMITH of South Carolina. So that when mixed for ordinary fertilizer that would be very small per ton?

Dr. WHITE. A very small royalty.

Mr. ROBERTS. Permit me to say this: You will find in Mr. Glasgow's letter the royalties we are going to pay at plant No. 2, the only one we are going to operate.

Senator SMITH of South Carolina. Before you go further, have you got the figures showing the relative increases of the use of nitrogen in all departments; in the munitions and in the arts and sciences, and in agriculture?

Dr. WHITE. In this country, do you mean?

Senator SMITH of South Carolina. Yes, in this country.

Mr. ROBERTS. We have here to follow Dr. White, Maj. Gaillard who has been studying that question, and we are going to have him give the figures of the supply and demand and necessity for atmospheric nitrogen, which he has, and which figures he will give you.

Senator SMITH of South Carolina. The thing I was interested in was the growth of the demand, showing if there was an increased consumption of this nitrogen, and I was interested to know just what departments absorbed the relative increasing production.

Col. BURNS. When Col. White gets through we will explain that fully.

Senator SMITH of South Carolina. All right, sir. The last step in the cyanamid process gives the cyanamid in powder form, is that the form in which it is toxic to the hand and plants?

Dr. WHITE. It is under some circumstances. After hydrating it is much less toxic. If the free lime is slacked, it is distinctly less toxic.

Senator SMITH of South Carolina. What is the total production in tons in Germany.

Dr. WHITE. About 500,000 tons of nitrogen.

The CHAIRMAN. We thank you, Dr. White.

Who is the next gentleman?

Mr. ROBERTS. Col. Joyes. Mr. Chairman, the Ordnance Department sent a commission of 4 officers to Europe in June of last year to investigate the art and industry in France, and in occupied German territory, and in England, and Col. Joyes now will report to you his findings, as he was at the head of that commission. Col. Joyes was also in charge of the Nitrate Division during the time of the construction of the Government nitrate plants.

STATEMENT OF COL. J. W. JOYES, NITRATE DIVISION, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Col. JOYES. I have prepared a short statement detailing some of the main things that I thought you would be interested in hearing.

This statement is intended briefly to present some of the information obtained and opinions formed by me during an official visit to Europe in the summer of 1919, especially bearing upon the plant development and costs of production of the cyanamid process and of the Haber synthetic ammonia process.

This visit to Europe was made as chairman and member of the United States Fixed Nitrogen Commission, appointed by the United States Fixed Nitrogen Administrator with the approval of the Secretary of War, to ascertain the state of the art of nitrogen fixation in Europe, and especially in the occupied German territory. The commission spent about two months abroad, visiting several cyanamid, and ammonia oxidizing plants in France and Germany, and the noted Haber plant of the Badische Co., at Oppau, for the synthetic manufacture of ammonia. The large arc plant in Norway was also visited, and many well-informed persons were interviewed.

In the need for nitrogen for the war, Germany was pressed hardest, because all importation of Chile saltpeter was stopped by the blockade, and munitions could not be made without a substitute material from which nitric acid could be produced.

The German government nitrogen administrator required the gas works and coke works to deliver all possible by-product ammonia, but no great increase could thus be made.

The government further increased ammonia production by requiring increases of existing cyanamid plants and construction of new ones, the government assisting by large loans, etc., and even building out of public funds two large cyanamid plants.

The Haber synthetic ammonia plant, which the Badische company had started to build at Oppau in 1912, was brought into successful operation just before the war, its first installment some 7,000 tons per year. Later this plant was increased to 100,000 tons per year, and another plant for 200,000 tons per year was built at Merseberg some three-quarters of its capacity having been developed when the armistice was signed.

Germany has a total present nitrogen capacity of about 300,000 tons by the Haber process, 120,000 by the cyanamid process, and 150,000 by coke ovens and gas works.

I may say, parenthetically, that the 120,000 tons by the cyanamid process is conservative. The actual capacity figured up is more than that. It has been stated by people who are well informed to be about 200,000 tons.

The CHAIRMAN. Does Germany use the arc process at all?

Col. JOYES. There are one or two small plants in Germany, but they are of no material significance. They have been put in for development work, and some of them are not operated at all now, and they are of no significance or no capacity at all comparable with these other processes.

The CHAIRMAN. The plants in Norway use the arc process altogether, do they not?

Col. JOYES. There is one large company there which runs two plants; and Norway has a large cyanamid plant also. In Sweden there are two large cyanamid plants and no arc plants to speak of; there was a project to build a plant in Sweden, but it was stopped.

The CHAIRMAN. The objection to the arc process is that it requires a large amount of power?

Col. JOYES. A prohibitive amount of power.

Senator SMITH of South Carolina. Before you go on there, you say there were 300,000 tons by the Haber process?

Col. JOYES. Yes; a year, as against 150,000 by the coke ovens and gas works and 120,000 by the cyanamid process.

France undertook the establishment of plants to produce by fixation at home nitrogen substitutes for Chilean nitrate sufficient in amount for all her home munitions manufacture.

The process selected as the backbone of this program was the cyanamid process and the plans contemplated adding to the prewar capacity (which was about 8,000 tons of nitrogen per annum) an aggregate annual production of over 50,000 tons of contained nitrogen, giving in all some 60,000 tons of nitrogen—to be available a small part before 1918, part in 1918, and all by May, 1918.

This program was largely financed by public funds, two of the nine plants being Government-owned, three being Government-controlled, and the others having probably some assistance in their financing.

Where possible these plants (or at least the carbide department) used water power, but from necessity some used steam power.

To utilize the ammonia produced by the cyanamid processes, six large oxidizing plants were started for producing nitric acid—the last to be completed early in 1919. A large part of these were Government-owned.

Great Britain was gravely concerned over the insecurity of her nitrogen supplies and early appointed a committee of prominent business men and eminent scientists to investigate and advise.

In its final report in May, 1919, the committee—after a complete analysis of all comparative data as to costs, yields, etc., and recognition of the scarcity of water powers in Britain, recommended: "as a minimum provision for safeguarding the future and for meeting a portion of the growing home demand for various nitrogen products" the establishment in Great Britain without delay "either by private enterprise (supported if necessary by the Government) or as a public work" of the calcium cyanamid process upon a scale of 60,000 tons per annum, which would mean about 12,000 tons of nitrogen fixed.

Italy had before the war capacity for some 7,000 tons of nitrogen by the cyanamid process. The present capacity is probably about 20,000 tons nitrogen.

Parenthetically I might say that Italy has several small plants of small capacity, but I left them out of this statement.

In Switzerland, Norway, Sweden, and other neutral countries, increase during the war period was a mere matter of business enterprise.

Cyanamid production capacity in these countries was increased by about 6,000 tons nitrogen in Norway and Sweden (with much more planned) and a small increase not definitely known in Switzerland.

Japan fully doubled her capacity and the United States planned for about 80,000 tons nitrogen, and completed one plant for 40,000 tons—the Muscle Shoals plant now under discussion.

I have not listed plant No. 1, because that is not in condition to produce yet.

Norway having cheap water power, doubled her arc process plants.

Throughout the world, therefore, the period of the war has seen large increases in the capacity for fixing nitrogen in useful forms. This has been most marked in Germany where the necessity was vital and next among the Allies, where the motive was mainly the national security.

In Germany and in France the need was so great that some of the plants were placed where conditions were so unfavorable that it was never expected that they could live after the war—but as far as possible they were placed and built with a view to future use in production for the needs of agriculture and the arts.

Deducting for plants so unfavorably placed as to be of use only during the war, and for plants under construction but not completed at the close of hostilities, I have formed upon information from many sources, the following opinion as to present capacity (exclusive of coke ovens) probably available for commercial production:

	Metric tons of nitrogen.
Germany:	
Haber	300,000
Cyanamid	93,000
	393,000
France:	
Cyanamid	40,000
Arc	1,000
	41,000
Italy:	
Cyanamid	12,000
Arc	1,000
	13,000
Scandinavia:	
Cyanamid	28,000
Arc	30,000
	58,000
Austria, cyanamid	22,000
Switzerland, cyanamid	7,500
Japan, cyanamid	12,000
Canada, cyanamid	12,000
United States (nitrate plant No. 2), cyanamid	40,000

Aggregate about 600,000 tons, of which some 270,000 tons is by cyanamid process and some 300,000 tons by Haber process.

The arc process has been used on a large scale only in Scandinavia where waterpower development and operative expense were very low. There are no reasons to expect early radical changes in its technique or economies, although these may come in time.

The cyanamid process has been growing in many countries for 15 years or so, and the apparatus and procedure have been so long studied that they are well established and revolutionary changes are not probable.

It is the one fixation process existing which, because it is not prohibitive in its power demands and is fully developed, was indicated as most advisable for prompt, reliable production at assured moderate cost. With reasonable power cost it fixes nitrogen in the cheapest usable form for agriculture—lime-nitrogen—and with cheap water power can compete in ammonia cost with the Haber process.

The Haber process is a new process, and large scale use brought many troubles, which under the war pressure, the large and efficient staff of the B. A. S. F. succeeded in overcoming so that the process is now a continuously-operating and fairly efficient plant to which the German company has linked up many auxiliary processes for adapting its ammonia to fertilizer uses. But our inspection indicated to us that up to the close of operation of the Oppau plant there had been constant modification and improvement of apparatus. Only a single ammonia converter at Oppau had all the latest improvements that we saw. It seemed clear to us that the Oppau plant showed need of still further improvement for entirely satisfactory operation.

At a good many points quite careful regulation of pressures, quantities, temperatures and composition of the gas-mixture, and a great number of gauges, meters, indicators, thermometers, etc., were provided to show the need for control by manipulation of a correspondingly large number of valves, switches, and the like.

It is said that fewer operatives are required than would be indicated by these controls, but making every allowance therefor, our commission was convinced that the labor and supervision forces must be quite large. In the estimates which have come from a number of sources, the expense of this item was not exorbitant because of the very low salaries and wages paid in Germany up to 1914, and it is upon such low rates, now no longer existent even in Germany, that the production of ammonia at quite low figures had been asserted.

Repairs and upkeep must be expensive.

It has been said that ammonia was made in this plant when it first started operation (1914–1915) for about 4 cents per pound, exclusive of interest, and with a small item of depreciation only, but it must be remembered that at that time lignite for fuel was available at about $2 per ton, and coke at about $4; that common labor received about 75 cents to $1 per day, and skilled labor between $1.40 and $1.50. These conditions have gone, and are not expected to return.

It was our firm conviction that under present conditions the production cost must be fully two and a half times as much.

If we assume this same plant set down in perfect condition in a favorable location in the United States, the costs of production under present price-conditions would be, in my opinion based upon our careful studies, as follows:

	Cost of ammonia.	
	Per short ton.	Per pound.
Plant cost of production (including cost of upkeep)	$209.00	$0.105
Amortization (depreciation and obsolescence)	75.00	.038
Interest, at 6 per cent on $750	45.00	.022
Sales expense	2.00	....
Aggregate cost	331.00	.165

Now, I have read you the figures that we have set down by careful calculations, and careful analysis of the plant as we saw it. And we have made some allowances for the time in which new organizations could get acquainted with the plant, and in talking it over with my fellow members of the committee we decided that it was a possible thing that after two or three years of operation, when an organization had become fully trained, some of these costs might be brought down a little. My experience would show that some reduction might be made in the amortization item, as we became familiar with the plant, it might not deteriorate so rapidly, so I have set down another set of figures, as follows:

	Cost of ammonia.	
	Per short ton.	Per pound.
Plant cost of production (including cost of upkeep)	$163.00	$0.082
Amortization (depreciation and obsolescence)	50.00	.025
Interest, at 6 per cent, on $750	45.00	.022
Sales expense	1.00	
Aggregate cost	259.00	.129

The **Chairman**. Do you know what the export tax is on Chilean nitrate?

Col. **Joyes**. About $11.60 per ton.

The larger figures for production assume some excess of personnel over what the Germans probably required, because of need for the personnel to learn a process new to them and very complex in its essence. The lower figures represent what might be attained after some years of familiarity with the process.

In course of time—that is, in some years of operation—it would be expected that American ideas would develop recording gauges, automatic controls, and other cost-reducing devices.

The first cost of the hypothetical plant is assumed as $750 per ton per year, which is much more than is stated for the German work done before or early in the war, but is not much more than recent work in Germany must be estimated. It is not too high for present American prices, considering the special nature of the equipment. It affects the upkeep item of production cost, the amortization, and the interest.

Upkeep is taken at 10 per cent of the cost of the plant for repair materials, parts, etc., and for replacements. Upkeep labor is included in the general labor item above. Considering the exacting conditions of the process and the newness of the process, this is not too much.

Amortization is taken at 10 per cent of cost of plant on the assumption that in 10 years there will be large obsolescence loss due to improvements in this new process.

The interest rate is assumed at 6 per cent on the assumed $750 cost of plant. This is probably too low.

We were told in Germany by a German official of a firm using ammonia that he did not believe Oppau could produce ammonia after the war for a total cost of less than 10 cents.

We have no basis for absolute comparison in the United States since the Government's plant experimentally built to use a similar but only partly developed process promptly developed troubles and the close of the war coming just at that time prevented the expenditure of the money necessary to overcome those troubles and make the plant operate. If the war had continued that would undoubtedly have been done, and the plant would have been made to make ammonia. But the experience showed conclusively that there would have had to be much development at much expense before the new American process could have equaled or nearly equaled the German or Haber process which had had already eight years or so of intensive study in commercial, if small-scale, apparatus, and several years of large-scale operation.

There is nothing to indicate that the Haber or similar process in its present state of development can, under present business conditions, in America, produce ammonia for as low a price as 10 cents per pound, exclusive of interest.

As I have already stated the matter of nitrogen supply was, during the war, energetically fostered by the German government, and specific control over all matters in that connection was exercised by an Imperial commissioner or commissary for nitrogen control under the War Department, who was given authority to issue regulations for the production and use of nitrogen products and for all traffic therein. In several publications the establishment of this control is mentioned in terms of high praise, and Walter Rathenau, in general charge of raw materials supplies, was given great praise for having initiated it.

In order to know the conditions affecting production by the several groups there were associated with this government administrator, Prof. Caro as representative of the cyanamide producers; Dr. Bueb, representing the Badische Anilin and Soda Works; and Geheimrath Bruckner, representing the by-product coke ovens. That was a strictly war control organization, but even before the war closed, Germany, with her usual foresight, was giving consideration to the future commercial aspects of her nitrogen works, and in August, 1919, there was definitely formed an association of the producers which was called the Stickstoff Syndakat G. m. b. H. or Nitrogen syndicate.

This designation is a commercial one and the organization is along commercial lines, but it is reliably stated that the establishment of this syndicate was largely due to governmental influence. This will be more easily understood if it be realized that the German Government had given financial assistance to many of the new plants and plant increases which the war had necessitated, and that it had also built out of public funds, two of the largest cyanamid plants in Germany.

The capital stock of this syndicate is held by the Badische Company, which makes synthetic ammonia; by the group of industrial companies and capitalists who manufactured cyanamid; and by the German Ammonia Sales Co. and the affiliated organizations of the coke works and gas works. Each of these three groups has one member on the board of directors, and the fourth member of that board is named by the Government. There will also be a board of managers of the company, the chairman of which will be named by the Government. Membership on this board, which will handle most of the business of the syndicate, is divided between the Government and the Badische Co., the by-product coke and coal industries, and the lime-nitrogen, or cyanamid industry.

The management of this syndicate will from time to time determine the limits within which the several groups may produce nitrogenous compounds, having made a preliminary allotment of production to the Badische Co. of 300,000 tons; the lime nitrogen, or cyanamid industry, 93,000 tons; the by-product industry 120,000 tons; and have, as a fundamental basis decreed that prices of any of these products shall be on the basis of nitrogen content as affected by a factor which is for lime nitrogen 8; for ammonium sulphate 9; and for saltpeter 10. That is, a given amount of nitrogen in those forms would be valued for sale purposes in the ratio of 8 : 9 and 10. All output is to be pooled, the sale of any one product depending upon its individual merits and popularity: but all plants manufacturing the same product will receive the same price. Exportation to be allowed only after all domestic demands have been met.

In order to safeguard other interests than those of the producer and to insure economy in distribution, there has, at the instigation of the Government finance ministry, been organized a joint body consisting of representatives of producers and consumers, known as the nitrogen commission. That commission will consist of 22 members: The nitrogen syndicate just mentioned, the Government, and representatives of the agriculturists of Germany will have five members each, and fertilizer manufacturers, fertilizer dealers, the bureau of industry and the bureau of agriculture, and three of the associate States will have one member each.

This information, which comes from most reliable sources and is not to be disputed, shows that beyond question anyone outside of Germany producing, or desiring to purchase nitrogenous fertilizers or similar compounds will have to deal with a single organization, essentially a branch of the German Government, which will have an absolute monopolistic control of all such products produced in Germany or whatever surplus there may be for export.

In France, the Government found itself in somewhat similar position as to actual governmental investment in fixation plants, although on a much smaller scale. During the war the Government became interested financially in nearly all of the expansion of nitrogen fixation, and it owned completely two of the cyanamid plants.

At the time of the commission's visit to France, the subject of utilization of the large cyanamid producing capacity created during the war, and especially of that part of it which was owned by the Government, was being discussed in the Chamber of Deputies and in the press. The urgent need for more use than previously of nitrogenous fertilizers by French agriculturists, on the one hand, and, on the other hand, the advisability of some measures to assure the continued operation of the war-created manufacturing facilities were being urged by men of such prominence as M. Pottevin, M. Roux, and M. Tisserand. There seemed to be very strong public opinion in favor of some arrangement which would insure the operation of the cyanamid plants. At the time of our visit no decision appeared to have been arrived at as to a definite plan of operation, but it appeared very probable that there would be some action by the Government, perhaps not as systematic and comprehensive as the German arrangement above described, but nevertheless one that would provide some basis of organization of the industry to meet the commercial outlook, possible German competition, etc.

Our commission saw installations in French Government plants for making ammonium sulphate out of cyanamid, and at one there was a very large scale installation of apparatus then (July, 1919) in process of erection for this same purpose. The French Government is, therefore, unquestionably in the market to some extent as a producer of ammonium sulphate.

Directly after the war the French Government had made temporary provision for the marketing of cyanamid as such by the appointment of an administrator.

The situation in Italy is not known, but rumors reached the commission that the Italian Government was to some extent interested in the cyanamid producing capacity with which that country emerged from the war period.

England, as intimated above, gave much attention to the nitrogen problem by way of study, but did not actually take any positive steps of consequence. England has been a producer of ammonium sulphate of which she exported a large quantity, while on the other hand there was some importation of other forms of combined nitrogen aside from Chilean nitrate. There was a strong recommendation from the nitrogen products committee, made at the close of the war, that the Government actually build a fair-sized cyanamid plant in England or Scotland, but it has not been learned that any definite steps had been taken toward the carrying out of that recommendation.

It is well known that although the Chilean nitrate workings are operated by private capital, the Government of Chile levies an export tax upon every ton of nitrate which leaves the country and that this tax is the predominating source of the Chilean Government's revenue. The Chilean producers are associated in quite a strong organization which has the sympathetic and more or less active backing of the Government.

The CHAIRMAN. May I ask this question, Colonel: What is the minimum amount of production that it will pay to erect a plant for to make it economically?

Col. JOYES. A cyanamid plant?

The CHAIRMAN. Yes.

Col. JOYES. I don't know that there is any definite hard and fast minimum, but naturally the economies expected would increase as you increase the size of the plant, unless it becomes too unwieldy. I have seen one plant working on a single carbide furnace.

The CHAIRMAN. I am asking that question for my own information. We live too far away from Muscle Shoals, we can not hope to get any of that product in the western country; the freight charges are against us. I understand, however, there are two things absolutely necessary in the production of this product—that is, power and water. We have 15,000,000 acres of lignite coal—15,000,000 acres underlaid with lignite coal right along the Missouri River, and we have layers of coal 60 feet deep. Now, would it not be possible for us up in that country—of course, there is nitrogen in the air out there as well as there is here—would it not be practicable for us to try to establish some of those plants out there?

Col. JOYES. It might be entirely practicable.

The CHAIRMAN. To save these tremendous freight charges?

Col. JOYES. Of course, the prime necessity in the establishment of a cyanamid plant is cheap power; cheap power and a pure quality of limestone, and some sort of carbon which would ordinarily be either coke or anthracite coal.

The CHAIRMAN. That is absolutely necessary in order to be able to make these materials?

Col. JOYES. Yes; those are the raw materials.

Senator SMITH of South Carolina. You started to describe one plant awhile ago which was a small single unit.

Col. JOYES. Yes; that plant was really a one carbide furnace plant; had only one carbide furnace in it, and they did not make cyanamid, as I recall it. They were putting up near it a small cyanamid plant which would take the product of about four or five carbide furnaces, and that, I should say, would be about the smallest cyanamid plant you could run.

Senator SMITH of South Carolina. What would be its capacity or production?

Col. JOYES. Probably about 15,000 tons or so; in that neighborhood. The source of that nitrogen is really the one thing that I think would be a definite limit, although that is not so very expensive. But one liquid air machine for making nitrogen would take care of quite a few ovens; but there are other possible ways of getting nitrogen. I do not think people as a rule figure down to get a small cyanamid plant, because your conditions are not for economy in a small plant.

The CHAIRMAN. Colonel, I am inclined to ask some questions, but I know so little about this matter that I might make myself ridiculous and call attention to the fact that I do not know what I am talking about. I am going to ask some questions anyhow, and if I do not indicate that I understand the situation, do not hesitate to call my attention to that fact.

In Norway they have the arc process and manufacture nitric acid?

Col. JOYES. As a first process?

The CHAIRMAN. As a first process.

Col. JOYES. Yes, sir.

The CHAIRMAN. That does not require any coal nor any limestone?

Col. JOYES. Nothing whatever; the only materials are air and water.

The CHAIRMAN. Air and water; that is all they use?

Mr. JOYES. Yes, sir.

The CHAIRMAN. Now, in our State we have, as I said, seven thousand billion tons, I believe it has been estimated, of lignite coal; all it would cost us is simply to mine it. I do not know how many thousands of billions of tons of air we have, because we have a whole lot of it. Now, would it not be possible for us, with that cheap lignite coal, to use the arc process?

Col. JOYES. It all rests on whether you can make your power cheap enough.

The CHAIRMAN. How cheaply would that low-grade coal have to be sold in order to be as cheap as the water power Norway has? I understand it costs $3 or $4 per horsepower year.

Col. JOYES. They developed their water power there as developed before the war for a capital cost of about $40 a horsepower. It is exceptional to get a horsepower in this country to be developed under $300; we used to say $200; that was cheap power development.

Senator SMITH of South Carolina. That was the initial cost?

Col. JOYES. That was the initial cost. Now, of course, all your fixed annual charges have to be calculated on that original cost and the capital you put into it.

The CHAIRMAN. What I had reference to, Colonel, more than anything else was the operating expenses after it had been installed.

Col. JOYES. The operating cost does not run very high on the water power. You might say it is negligible; very, very low. I think, all things considered, they have figured the cost of a horsepower for a year in Norway at around $4.

The CHAIRMAN. Yes; I think that is it.

Col. JOYES. Four dollars per horsepower for the whole year.

Senator SMITH of South Carolina. That is for the use, after it is developed?

Col. JOYES. Yes; after it is developed. Interest on the development and operating expenses, and all.

The CHAIRMAN. That is overhead and carrying charges, and everything?

Col. JOYES. Yes, sir.

The CHAIRMAN. You agree with Mr. Washburn in that statement.

Col. JOYES. It is undoubtedly very low.

Senator SMITH of South Carolina. About what is it in this country?

Col. JOYES. Well, they have had at Niagara Falls—there are some of the earlier contracts out there—some of the earlier contracts ran between $10 and $15; I do not know the exact figures; somewhere between $10 and $15. And later contracts have been considerably higher; I think $25, or higher.

Senator SMITH of South Carolina. Taking the cost of installing the plant at Muscle Shoals, and the possible development of the power there, about what would be your idea of the cost per year per horsepower?

Col. JOYES. I am not an expert on that, and I do not believe my opinion would be of very much value to you, sir. It is an opinion that is difficult to give. It depends on how much power you develop and how much power you get out of it. I think I had rather pass that question to Mr. Roberts.

Senator SMITH of South Carolina. Mr. Roberts, about what is it?

Mr. ROBERTS. I want to go back and answer Senator Gronna's question. Senator, before the war, on the best and most economical steam electric light plant I ever knew, they used coal at $3.25 at the plant, and it only had to be taken up in the bins, which cost very little. With the price of labor then, in 1914 and 1915, the cost was, to be exact about 0.28 of a cent, without amortization, interest, or taxes. Now, you see that is going to make the price of steam power in Dakota with your cheap coal quite an item.

The CHAIRMAN. What class of coal are you speaking of?

Mr. ROBERTS. I am now speaking of coal which will run about 14,000 B. t. u. per pound, which is very high. Lignite will probably not run more than about 11,500. Your coal probably will not run as much as that, and you can not get as high an efficiency out of that coal, because there is some loss in the ash; so you will not be able to do anything with the arc process.

The CHAIRMAN. There was a time they used to buy it for 75 cents a ton, loaded on the cars.

Mr. ROBERTS. Yes; but you would not get as low a cost as 0.28 of a cent, even with that price, and the high price of labor. We are now, in Alabama, figuring it will cost us 0.4 of a cent, which would be very nearly $25 a horsepower year.

Now, to go to Senator Smith's question: The operation of the Muscle Shoals plant, without any depreciation or amortization for the water power will be one-fourth of a mill per kilowatt hour.

Senator SMITH of South Carolina. Now, that expressed in horsepower——

Mr. ROBERTS (interposing). Now, sir; I will tell you—if it was 1 mill per horsepower year, it would cost you at 1 mill $6.53; now, one-quarter of that would be about $1.63.

Senator SMITH of South Carolina. That is in addition to the $6?

Mr. ROBERTS. Oh, no; the actual production at Muscle Shoals will be $1.63 per kilowatt year. That does not include depreciation, amortization, or taxes.

Senator SMITH of South Carolina. If you have calculated this, what, in round numbers, would be the commercial value?

Mr. ROBERTS. Of what, you mean?

Senator SMITH of South Carolina. Of the horsepower that you have developed out at Muscle Shoals?

Mr. ROBERTS. That is what I have just told you.

Senator SMITH of South Carolina. I want you to add in all the items that necessarily would come in, for depreciation, in this amortization, and so forth.

Mr. ROBERTS. Well, I would have to know, to get the interest—I would have to know what the dam is going to cost; I have never made that estimate.

Senator SMITH of South Carolina. The reason I am asking these questions, we are here asked to legislate for the Government to go into this business.

Mr. ROBERTS. Yes, sir.

Senator SMITH of South Carolina. We have about got the plant completed.

Mr. ROBERTS. Yes; but we haven't got the dam completed.

Senator SMITH of South Carolina. But you haven't the power completed?

Mr. ROBERTS. But the power is being arranged for and being installed; the dam is being built.

The CHAIRMAN. Mr. Roberts, am I right in assuming that your estimate is only labor cost?

Mr. ROBERTS. Labor and repairs.

Mr. CHAIRMAN. And nothing else?

Mr. ROBERTS. And nothing else.

Senator SMITH of South Carolina. Now, I want to ask this question in connection with——

Mr. ROBERTS (interposing). We will say this to you—we have taken in our estimate for the cost of the production of cyanamid power at three-fourths of a mill, or three times this figure; that is, figuring for amortization and depreciation and repairs, and all other items, except interest.

Senator SMITH of South Carolina. This morning the question was asked, after the dam was completed and the power was developed, what would be the primary horsepower, and I believe it was about 100,000 horsepower; now, if all that power were utilized, let us say, in the present development of the cyanamid process——

Mr. ROBERTS (interposing). Yes.

Senator SMITH of South Carolina). If you were to use all that in the production of cyanamid, what would be the capacity of the plant, using 100,000 horsepower per year?

Mr. ROBERTS. The capacity of the plant in cyanamid?

Senator SMITH of South Carolina. Yes.

Mr. ROBERTS. Two hundred and forty thousand tons.

Senator SMITH of South Carolina. Two hundred and forty thousand tons if the whole water power capacity is used?

Mr. ROBERTS. A hundred thousand horse power?

Senator SMITH of South Carolina. Yes. Now, with the installation of a plant sufficient to use the secondary power during the flood stage——

Mr. ROBERTS (interposing). Yes.

Senator SMITH of South Carolina. Have you calculated about what could be produced at Muscle Shoals, utilizing all the power that might be generated in an average during the year?

Mr. ROBERTS. Why, I can tell that. We can make it 200,000 horsepower, and we would have to supplement that by one-ninth of that with steam power. In other words, we can carry through the year 200,000 horsepower by taking the total amount of horsepower developed by water in the year and adding one-ninth, which we would have to do using the steam plant, which is already built. So, we can count on 200,000 primary horsepower, because we have got this steam plant already built, and we will only operate it one-ninth of the year, so that during the year you can calculate on 200,000 primary horsepower, with the use of additional power at other times.

Senator SMITH of South Carolina. Have you figured out what could be the practical capacity at that plant if it were developed to use all the power that would be obtainable?

Mr. ROBERTS. That would be just as I said to you; with our present steam plant and water-power plant, 200,000 horsepower, primary power. There are stages in that river that come for practically six months in the year that we could make at least 350,000 horsepower.

Senator SMITH of South Carolina. Now, you make how many tons per horsepower?

Mr. ROBERTS. Well, with a hundred thousand horsepower development we make 240,000 tons of commercial cyanamid.

Senator SMITH of South Carolina. So that you can approximate, then, that would be 560,000—480,000 tons?

Gen. WILLIAMS. That would require addition to the plant, though.

Senator SMITH of South Carolina. I meant if you would complete the dam, develop all the power, what would be the capacity by utilizing all the power? Because it stands to reason that if you develop the full capacity of that water power, you would be wanting the plant to use it—a sufficient plant to utilize the power.

Gen. **Williams**. With the present plant for the fixation of nitrogen, we would not need that 200,000 horsepower.

Senator **Smith** of South Carolina. But, after we have got this plant established, if it is economical, then we would want to establish another, so as to use whatever additional power we had from the development of the plant.

Col. **Burns**. But we would have to come back here and ask for more appropriation.

Senator **Smith** of South Carolina. Not if you make sufficient profit, like we did on some of our cotton mills.

Col. **Burns**. Yes.

Senator **Smith** of South Carolina. If you could save enough out of this, maybe we could build another plant. You say you are figuring on about $16 profit, and if we get that into the Treasury we might develop another plant. The feature of this thing is, of course, we can calculate no cost when a war necessity is on us, and the danger of our foreign supply being cut off. No one would figure on cost, providing we could get the material to save our national life; but the use of this material in the fertilization of our land is, according to the figures shown there to-night, of prime necessity to this country, and it is our duty here and now to provide the initial step for the development of those plants that would secure for us a cheap and adequate supply of nitrogen for agricultural purposes. I believe you said to-day that you could develop this for around, under present conditions, about $65 a ton for the commercial form in which it is used?

Mr. **Roberts**. I said we could sell it for that.

Senator **Smith** of South Carolina. Yes; sell it for that, without profit.

Mr. **Roberts**. With a profit.

Senator **Smith** of South Carolina. Those thoughts will largely determine the attitude of a good many on this question; and also the supply, the amount that we can get from the operation of this plant. Of course——

Gen. **Williams** (interposing). Senator, in so far as we are concerned, we had to consider the fact that we would have a surplus beyond what would be needed by the present plant that is installed there, and that in case of necessity that a simple thing, an easy thing, and a natural thing for us to do would be to increase the capacity of the present plant up to the power capacity of the dam and the steam plant that we have there.

Senator **Smith** of South Carolina. That is my idea, that if you are going to build this dam and develop this power for this purpose, then it would be the part of economy if it proved a practical thing to build a plant that would consume to the capacity of your power. Now, this cyanamid process—sulphate of ammonia is the more valuable for fertilizer—for use in fertilizing which of the two is the more costly?

Mr. **Roberts**. Why, of course, the sulphate of ammonia is the more costly, for the reason that after we have made our cyanamip we have got to convert it into ammonia.

Senator **Smith** of South Carolina. At what additional cost?

Mr. **Roberts**. Let us see. Now, after the water power is developed—when we have the water power developed the cost of the cyanamid is $27 a ton; but the cost of the sulphate is $48.20 a ton; $21.20 difference.

Senator SMITH of South Carolina. They are both the same in percentage?

Mr. ROBERTS. Both of the same per cent in nitrogen.

Senator SMITH of South Carolina. It is the latter that will be valuable for fertilizing?

Mr. ROBERTS. Now, we have established here in Washington a research laboratory that is working on these things, and we hope that we are going to overcome the trouble of cyanamid, and make that really good for fertilizer, so that the farmer can use it, and remove its toxic features; and we hope that we are going to get that, and we are working on it. After you get through with Col. Joyes I am going to have Dr. Lamb tell you about some of the work that we have done in the research laboratory. I think that we will overcome the disabilities of cyanamid; of course, that is a hope. But our dependence now in coming to you to operate this plant is sulphate of ammonia, and we are basing our life upon that. We are not basing it upon cyanamid at all. We only expect to sell a small part of our output as cyanamid to go to the fertilizer mixers, who now buy from the American Cyanamid Co., and, of course, as the fertilizer business grows they will use it more and more as they mix more tons of fertilizer, and, therefore, we will have some demand for cyanamid; but we are basing our profits and everything upon sulphate of ammonia. We are going to make some nitrate of ammonia, because it can be sold to the dynamite people in the South, and a great deal of dynamite is being used for road making and ditching, and clearing land of stumps and other purposes; and we will also carry through, because nitrate of ammonia is one of the things that is used in the Army, and we want to keep that part of the plant always ready to operate.

Senator SMITH of South Carolina. How do you find the demand for cyanamid from fertilizer mixers?

Mr. ROBERTS. About 60 pounds to the ton of mixed fertilizer.

Senator SMITH of South Carolina. Do you find that they are buying it readily? Of course they use cottonseed meal and tankage and blood. Do you find that they buy it readily?

Mr. ROBERTS. They will buy it up to 60 pounds to the ton, readily. They will buy it readily if they—I have been talking to various people, to the Virginia-Carolina Chemical, the American Agricultural Chemical, and the International, and the presidents of those companies—none of them have any objection to taking it up to 60 pounds; they might go to 80, but they will go to 60 readily; there will not be any trouble about selling that much. But we really sell sulphate of ammonia; that is what we are going to sell, and if any of the mixers come around and want any cyanamid we will let them have it, because it is the first thing we make, and the next thing is the sulphate of ammonia, and that can be sold as well as the Chilean nitrate, and is just as well known.

Senator SMITH of South Carolina. And it is easily handled?

Mr. ROBERTS. Just as easily as the Chilean nitrate. It has been known and used for 50 years by the farmers, and by all the users of Chilean nitrate.

The CHAIRMAN. Is there anything further you wish to say, Col. Joyes?

Col. JOYES. No, sir.

Senator SMITH of South Carolina. I would like to ask this question, Mr. Chairman.

The CHAIRMAN. Yes.

Senator SMITH of South Carolina. He indicates there that the Germans produced nitrogen by the Haber process.

Col. JOYES. Yes, sir.

Senator SMITH of South Carolina. You say that from your observation the construction of the plant and the necessary operation of it, in your opinion, was too costly to be adapted to conditions in this country. Did I so understand?

Col. JOYES. Well, I would hardly put it that way, sir. I said that I thought to bring it over here just as they had it and install it in this country in a favorable location that ammonia would cost us, say, for a couple of years, 16½ cents a pound, everything included, and after two or three years' experience that the price might come down to 13 cents.

Senator SMITH of South Carolina. The point I wanted to get was this, why did the Germans use that process to such an extent over the cyanamid process?

Col. JOYES. Because they had no water power in Germany to speak of, and they wanted a process that did not need any great quantity of power. Now, these three processes all take some power to operate, naturally. You take the Arc process, it will take about 10½ to 11 horsepower; take the cyanamid, it takes a little over 2 horsepower, and the Haber about a quarter of a horsepower. You see the range in the ratios are pretty wide there. And therefore, to install cyanamid plants to give her all her war needs for nitrogen, would have taken very large installations, and not having any water power she would have had to look to steam power.

Now, she did not have all the necessary steam-power plants available. Now, not having water power, they went and took some new steam-power plants that had recently been completed. They had not all their load on yet, and they built those plants to take that steam power. In other places they had a little water power, and they used that to the limit; but they had not very much. Now, up in Saxony they had some power plants there, pretty good-sized ones; they ran on lignite, and they had enough power there; it was not so awfully cheap, but they had the power, and that was what they were looking for. Well, they put a great big plant there, for about 130,000 to 200,000 tons of cyanamid a year. They put another down in the hard-coal region; that was a bigger one still, over 200,000 tons per year, about the largest they had; so that they had used up, by their cyanamid process, all the big steam-power plants that they could spare, and it would take them a long time to build any more, so they were glad to find a process that did not require more power.

Senator SMITH of South Carolina. Well, then, would it not be cheaper to get the nitrogen through the Haber process?

Col. JOYES. No, sir, if you have your power cheap you can make your product cheaper by the cyanamid process. But the question with the Germans was not economy of money, but economy of time. They wanted the output. and to depend upon it by a certain time.

Their stock of nitrogen at the beginning of the war would not have seen them anywhere near through 1915 if they had not put up these plants and got them going. Now, the first thing they did was to tap the coke ovens and take their ammonia and make nitrate of soda out of it, and they had those going to the tune of about 30,000 tons of nitric acid a month before the middle of 1915. Then they started to increase the production of ammonia. They did that in the best and most available way; they pressed their coke ovens and gas works all they could. It is said they even required the railroads to burn half of their fuel coke, to enable the coke ovens to put out more ammonia and other by-products; they had not time to build new coke ovens, and they next took up cyanamid, which they knew all about, and they put in all the plants around Germany where they could get any power. Meanwhile, they were running this Haber process. Well, before the war they were making thirty-five or forty thousand tons of sulphate per annum, and 7,000 tons, say, of ammonia, proper, and they increased that by four or five times, according to Badische's original plan; and the Government increased it still further, bringing it from 35,000 up to 100,000 tons. They pushed that as fast as they could. Then they started immediately to build a great big plant at Merseburg, twice as big as this first one. They started that about the beginning of 1916, or in 1915.

The CHAIRMAN. If there are no further questions, we will hear the next gentleman.

Mr. ROBERTS. Dr. Lamb is the next.

STATEMENT OF DR. ARTHUR B. LAMB, DIRECTOR OF THE FIXED NITROGEN RESEARCH LABORATORY, NITRATE DIVISION, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Dr. LAMB. Mr. Chairman, I have come prepared to tell the committee how little we know, and how much we need to study and investigate this subject. I will condense what I have to say into a brief space, but I have submitted a complete statement to the stenographer.

The CHAIRMAN. We will have it printed.

Dr. LAMB. I think I can start what I have to say by assuming that you will all admit that we must be able to compete with foreign nations in the manufacture of fixed nitrogen, at least in our home markets. In times of peace we must have fertilizer at as low a price as foreign nations enjoy it, or as they could sell it here, and in times of war we have got to know how to make it, so we may have military security.

The CHAIRMAN. We all agree on that.

Dr. LAMB. We can not hope to compete successfully in any contest unless we have had the experience and training that is necessary; and possibly because I have been connected with the Research Laboratory, and have been endeavoring to solve some of these problems, I appreciate better than others how little we really do know.

We may as well be frank here. We know very little about the art of nitrogen fixation in this country, with the single exception of the cyanamid process, which is the one we are going to operate. Now, we feel we do know about that process. We have got the best plant in the world; we did not see a better plant anywhere in

Germany, or elsewhere, than this one of our own. On the other hand, the other processes, which will compete with this process, are pretty nearly unknown to us. The Germans got their information on these processes more or less as a matter of necessity, as has been pointed out, but they are now making full use of the advantage which they have gained.

The knowledge which they have gotten of the fixation of nitrogen can be classed under two heads. In the first place, they understand the Haber process very thoroughly. They have worked out every step in it. They have constructed tremendous plants. I do not believe there is any material monument to human intelligence in the world any greater than the tremendous, complicated plant at Oppau, or the one at Merseburg, which is said to be still bigger. But aside from their knowledge of the Haber process, about which we know so little, they have perfected methods of converting the ammonia, which they get in that process, into fertilizer material. This they have done in a number of interesting ways. In the first place, they worked out methods of making it into ammonium sulphate, which is what we are going to do, and they perfected that. I do not know that they will do that much better than we hope to do it, though.

Senator SMITH of South Carolina. That is through the Haber process?

Dr. LAMB. They get their ammonia by the Haber and we by the cyanamid process, but the problem is the same from there on.

The CHAIRMAN. Is Germany the only country that understands that Haber process?

Dr. LAMB. Yes; quite the only country that thoroughly understands it.

The CHAIRMAN. Well, we are paying a royalty to those who own the patent on the cyanamid process. Would not it be possible to get the formula or to get the patent or to be allowed to use the patent on this other process in some way?

Dr. LAMB. I do not know.

The CHAIRMAN. I am speaking now of times of peace, of course.

Dr. LAMB. I think Germany looks on this industry as a national business, and how willing she would be to sell her information I do not know. The Germans told us when we were there that they would be willing to tell the French all about the process, to show them all the valves, and just how to turn them, and to give them all the formulas, and then they were confident that they would not be able to run it. It had taken them years to learn how, and the mere statement of the chemical formulas involved was only the beginning of the thing.

The CHAIRMAN. So the only way we can acquire it will be to experiment with it?

Dr. LAMB. Yes, sir; that is my firm conviction. Now, in addition to making ammonium sulphate by mixing the ammonia and the sulphuric acid, the Germans have worked out an elaborate, and an apparently very successful method of replacing the sulphuric acid by ground gypsum rock, which costs only a quarter of what the sulphuric acid does. Together with it they use carbon dioxide, which they obtain as a waste product from another branch of the plant, and from these two cheap sources they obtain ammonium sulphate in a somewhat cheaper way. Of course, ammonium sulphate's basic price is the price of ammonia; you must add to it the price of sulphuric acid. And if we can make that second figure small the resulting product is relatively cheap.

Mr. **Roberts.** But we have not got the gypsum.

Dr. **Lamb.** Well, I do not think that we are in quite as desperate straits in this particular respect as Germany, since our sulphuric acid can be produced very cheaply at Muscle Shoals and can be purchased very cheaply there.

But in addition to this the Germans succeeded in treating ammonia with common salt and carbon dioxide by well-recognized methods, but by a combination that was not so well known, and got the ammonia fixed as ammonium chloride. They have demonstrated that ammonium chloride is just as good as ammonium sulphate, and at the same time they obtain sodium carbonate as a by-product.

That is one thing that they have accomplished. They have also perfected the conversion of ammonia and carbon dioxide into a substance called urea, in which the nitrogen is much more concentrated; its percentage is twice what it is in ammonium sulphate, and they have demonstrated that it, too, has valuable fertilizing qualities.

Now, all of these processes are of interest, and they represent the type of things that the Germans have done. We do not want to give the impression that they are so far ahead of us that we can not catch up. As a matter of fact, we have certain advantages ourselves, and we have already made starts on many of these problems, which are very promising. Instead of fixing the ammonia as ammonium sulphate, which of course is what we are going to do on a large scale, because that is the thing we understand and what will make our money, but looking to the future, I see as a possibility the replacement of the sulphate part of ammonium sulphate by something that will fix the ammonia just as well, will bind it as a solid, and yet have fertilizing value. We are proposing the use of phosphoric acid——

Senator **Smith** of South Carolina (interposing). I had heard that discussed some time, when I was down in the State, and I had heard that it was probably possible that they might use the phosphate rock as a basis for the fixation of ammonia. Then, if you do, you only lack one other ingredient for having a plant fertilizer.

Dr. **Lamb.** Well, sir, we have found that it is not at all difficult, by a proper regulation of conditions, to absorb ammonia directly in commercial superphosphate; that under suitable conditions one gets in this way from 6 to 8 per cent of ammonia and 12 to 14 per cent of phosphoric acid present at the same time, that is as phosphate, and this gives a decidedly more concentrated fertilizer than the ordinary mixed fertilizer, and of course will be subject to lower freight charges. There are some difficulties connected with this proposal; the products we have made so far do not keep as they should, so that we know there is more work to be done on that before the process is successful.

But there is an even more hopeful method which we are working on, and that is to take phosphate rock and by an electric furnace treatment to liberate the phosphoric acid and use that directly instead of the superphosphate to combine with the ammonia and form phosphate of ammonia, which is free from all of the diluting ingredients that are present in superphosphate. It will run about 14 per cent ammonia and 86 per cent phosphate—no waste to it at all. It will represent a very concentrated fertilizer, such as we could perhaps even afford to ship to Dakota, so you may not need to build your plant out there.

Senator SMITH of South Carolina. Well, you have very rich phosphate beds not very far from this plant, have you not?

Dr. LAMB. Yes, sir; within a hundred miles we have extensive deposits of a very high per cent phosphate rock; almost an unlimited amount. And, to cap the climax, they have, as you suggested, right in Georgia, not far away, deposits of potash in the so-called green shales. Now, this is perhaps a little fanciful, and one should not be too optimistic, but it looks possible by suitable treatment to obtain the potash from these shales and combining it and the phosphate with the ammonia from the cyanamid to at once have a completely balanced fertilizer, containing all three of the chief ingredients required by plant life.

Senator SMITH of South Carolina. May I ask you the extent of those potash shales in Georgia?

Dr. LAMB. Well, we have looked into it a little, in so far as we could from the reports of the State geologist, and they are not as extensive as the potash deposits of Germany by a good deal; but I do think they will be adequate to supply our particular plants for a long period.

The CHAIRMAN. Do you think we could do that more cheaply than by the system we have out on the Pacific coast, manufacturing from kelp?

Dr. LAMB. I do not know that we could do so any more cheaply, and, indeed, I should hesitate to say much about the price at which we could do this. It is pretty fanciful; it is just the possibility that I want to point out.

In conclusion, I do not know that I can do anything better than to tell you how the Germans have faced this problem and what attitude they have taken toward it. The Oppau Plant, that is, the Haber Plant, was constructed about 1913, and it had an output of approximately seven or eight thousand tons a year. Then, as the war sentiment grew, the plant was greatly increased. They had operated this process at that time for some years, and they already had a plant of a size comparable to your own plant at Sheffield, and yet when they designed the building for their new enlarged plant, the one that is now working, the largest and most expensive building that they constructed—it cost 3,000,000 marks even at that time to build—was the Research Laboratory. It is 300 feet long, 100 feet wide, and five stories high. When we were there in the summer of 1919, this last summer, when everything was over and the plant was shut down, they still had 75 chemists working in that building on research problems, while during the war we were told that they had 250 chemists working all the time on research problems, not including the control chemists, who were housed elsewhere in the plant. So that is the scale on which Germany continued her studies at a time when she had already solved the problem and was engaged in large scale operations. So, we must not forget that in facing this matter we have got a good deal of study and investigation before us if we are going to hold our own.

Senator **Smith** of South Carolina. It is your opinion that considering the perfection to which the cyanamid process has already been brought it is possible to still further perfect and cheapen the process?

Dr. **Lamb**. Yes, sir; indeed, I have, in my more elaborate brief, outlined half a dozen possibilities, or perhaps four or five possibilities, where I think considerable economy can be effected, so that even above the figures that Mr. Roberts has given you, at length, I am confident that by research and experience and study in the future we can make reductions.

Senator **Smith** of South Carolina. Following out the suggestion of the chairman, Senator Gronna, is it your observation that small units may be economically installed?

Dr. **Lamb**. I do not think that the cyanamid process is especially adapted to small scale operation. The carbide furnace, on which it depends, is itself a rather large scale installation. Its success depends upon the utilization of the electrical energy, and that means that you must waste as little of that energy in the form of heat as possible. That means fairly large units, so that you will not have too much radiation losses.

Senator **Smith** of South Carolina. Does the Haber process indicate any difference from that statement. Would it lend itself to any smaller units?

Dr. **Lamb**. No; I think it must be worked on a very large scale, due to its very complicated nature, and elaborate apparatus, and to the fact that it must be tuned up and has to run like a watch to operate successfully. Even at the time we were there they told us that the various units, the various parts of the plant required practice; they had to get going for a week or two weeks before the whole plant got into operation, so as to get everything running at the right rate, and then they all started.

The **Chairman**. Is there any further question that the committee wishes to ask?

(The paper presented by Dr. Lamb is here printed in full, as follows.)

THE NECESSITY OF GOVERNMENTAL RESEARCH ON NITROGEN FIXATION.

Other representatives of the Nitrate Division have demonstrated that the Government should operate the splendid plants at Muscle Shoals for the sake of the abundant supply of nitrogenous fertilizer which they will provide. Still other representatives have shown that these plants should be operated so that they may be maintained in a state of instant readiness and efficiency and so afford that military security which was the chief motive for their erection. It is my special purpose to demonstrate that the Government should operate the plants, so that we may acquire promptly in this country knowledge of and experience with the important industry of nitrogen fixation.

Such knowledge and experience is of the utmost importance. You will concede, gentlemen, that we must be able to compete successfully with foreign countries in this essential industry at least in our home markets. In peace times we can not afford to pay more than they do for the fertilizer on which the productivity of our land depends; in war times we can not with safety rely on foreign supplies for the chief ingredient of our explosives. If we are to compete successfully we must not only understand the chemistry of the processes, but we must have experience in their operation.

Moreover, the science of nitrogen fixation is still in its infancy; it has problems which are difficult and numerous; there must be extensive research by the chemists in the laboratory; the products which they produce must be tested by agricultural experts on a convincing scale, and the methods of manufacture developed in the laboratory must be translated by the engineer into large-scale operation. Irrespective of whether the Muscle Shoals plants are to be operated or not, these investigations should be supported actively and aggressively by the Government, but evidently they would be greatly facilitated and simplified if carried on in connection with the Government operation of the Muscle Shoals plants.

Col. White has already outlined the processes employed throughout the world for nitrogen fixation. It is worth pointing out that in spite of their present-day importance these processes are nevertheless very new. The arc process, the oldest of them all, has been in commercial operation less than 20 years; the cyanamid process, which so far as made more fixed nitrogen than any other, has been in operation but 15 years, while the Haber process, which although confined to but two plants, is now making fixed nitrogen more rapidly than any other, is but five or six years old.

It is not strange, therefore, that there should be great possibilities for the further improvement of these processes. I shall point out some of the more evident possibilities in this direction, as follows:

In the arc process only 2 per cent of the electric power consumed is actually utilized in binding the nitrogen and oxygen together; the rest is lost as waste heat. In spite of this, the arc process is able to operate successfully in Norway and Switzerland, where power is very cheap. Now, the actual way in which the binding action is brought about by the arc is still a mystery. It is certainly reasonable to think that if this mystery could be solved conditions might be so modified as to utilize a much greater fraction of the electric energy. This possibility surely seems worth studying.

Again, the compounds of nitrogen and oxygen formed in the arc are not easy to catch and absorb. Large and costly towers of granite, filled with broken quartz rock, are required, and the interest charges on this installation constitute another important item of expense. We already have indications how these immense towers can be replaced by much smaller and simpler ones if they are filled with suitable absorbents. A further investigation of this possibility appears most desirable.

There are also many opportunities for improvement in the cyanamid process. In the first place, the product itself, lime-nitrogen, has great possibilities. It is beyond question the cheapest known form of artificial fixed nitrogen. When properly prepared and used, its fertilizing value is very nearly as great as that of sodium nitrate or ammonium sulphate. Its nitrogen can, of course, be converted into the other well-known nitrogenous fertilizers, such as nitrates and ammonia salts, but the cost of the nitrogen in these compounds is increased by every added step, so it is evidently for the best interest of the country to use it directly as a fertilizer whenever possible.

There are, however, inconveniences in its use which have not as yet been wholly overcome. In the first place, it is inclined to be dusty, and the dust is irritating to the skin. This can doubtless be remedied by converting the dust into granules, with a suitable binder. Considerable progress along this line has already been made, and there is decided hope for an entirely satisfactory solution.

Again, lime-nitrogen contains a considerable quantity of unchanged lime. This is of real value to the farmer, for it corrects one of the most widespread difficulties which he has to contend, namely, acidity of the soil. On the other hand, in this country, we chiefly use nitrogenous fertilizers mixed with superphosphate and, unfortunately, the lime in the lime-nitrogen renders the phosphate less soluble and therefore less readily available as plant food; that is, in putting in one food we make another less available.

This difficulty could be avoided if some other sort of soluable phosphate, which would not be affected by the lime, could be produced cheaply enough to compete in price with superphosphate. We know that it is possible to convert phosphate rock into a more soluble modification by calcining it under proper conditions at a high temperature. This variety of soluable phosphate can be mixed freely with lime-nitrogen without any ill effect. But it remains to find how to carry out this process cheaply enough.

These possibilities for the wider, direct use of lime-nitrogen are attractive and promising, but their study and development will take some time. It is therefore planned at Muscle Shoals to convert the nitrogen in most of the lime-nitrogen into ammonia and to bind this with sulphuric acid. This is unquestionably a wise procedure at present, because each step is thoroughly understood, and the product is well known and in great demand.

The sulphate part of ammonium sulphate, however, is a dead loss so far as the farmer is concerned. Its only purpose is to hold the ammonia, which otherwise would escape as a gas. It would evidently be much better to bind the ammonia with the material which itself has fertilizer value.

We have found that superphosphate absorbs ammonia rapidly and binds it firmly, and that by a proper regulation of conditions we can secure in this way a fertilizer containing 6 to 8 per cent of nitrogen and 12 to 14 per cent of soluable phosphoric acid. This is about twice as concentrated as an ordinary mixed fertilizer. Unfortunately, the products thus far prepared deteriorate on standing, but it appears possible to obviate this by further experimentation and research.

Another method, and an even more attractive one, is to combine the ammonia directly with phosphoric acid instead of superphosphate. Phosphoric acid can be made from phosphate rock either by the use of sulphuric acid, or better still by means of the electric furnace. By this latter means the phosphoric acid is driven out of the phosphate rock and is collected from the escaping gases. The compound of ammonia and phosphoric acid, ammonium phosphate, or "ammo-phos," as it is called commercially, has very desirable qualifications. It is many times as concentrated as ordinary commercial mixed fertilizer. This means that the freight charges upon it will be very much less, and since freight charges are a limiting factor in the fertilizer supply for many parts of the country, it means a much wider utilization of fertilizer, and an increased production of food.

Not only is this ammonium phosphate a nearly ideal fertilizer, but it is ideally suited for manufacture at the Muscle Shoals plants. In the first place, the cheap electric energy required for the electric furnaces is directly available, and, in the second place, there are rich deposits of high precentage phosphate rock within 100 miles of the plants.

Finally, to cap the climax, there are extensive deposits of potash-bearing feldspars in Georgia, also quite near the Muscle Shoals plants. Potash is the third of the three important ingredients of a complete fertilizer. It is possible by electric furnace treatment to volatilize the potash from these materials, and it is not at all improbable that by a suitable combination of this procedure with the electric furnace method for the manufacture of phosphoric acid, both potash and phosphate could be obtained, and when combined with the ammonia from the lime-nitrogen would constitute a complete fertilizer, containing all three of the necessary plant foods.

The above research possibilities all have to do with the utilization of the lime-nitrogen. There are also important possibilities for improvements in the actual process of manufacturing this substance.

1. *Recovery of carbon monoxide.*—The first step in the production of lime-nitrogen is the manufacture of calcium carbide. In this manufacture a large part of the energy consumed is lost in the carbon monoxide which is given off from the carbide furnaces. So far, attempts to collect this gas have interfered with the operation of the furnaces themselves so as to increase rather than decrease the cost. It is certain that by a careful study of this problem some satisfactory solution of this difficulty can be found.

2. *Substitution of fuel for electric heatin?.*—In making the calcium carbide the heating is at present carried on exclusively in electric furnaces, and the electrical energy consumed constitutes an important fraction of the cost of carbide; yet the temperature required for this reaction is well within the range of an oxygen-fed gas flame, and the oxygen is available almost without charge from the liquid air plants furnishing the nitrogen for the subsequent nitrification of the carbide.

If a furnace suitably fired in this way could be substituted for the electric furnace, the saving in the cost of lime-nitrogen would be very considerable, probably as much as 25 per cent.

3. *Improvement in nitrification process.*—Almost nothing is definitely known regarding the formation of calcium cyanamide from calcium carbide in the nitrification process. The furnaces are operated by rule-of-thumb methods, and the function of the so-called catalyst employed is by no means understood. It appears almost certain that if this important reaction were aetively studied a more economical and efficient operation could be achieved.

4. *Recovery of graphite.*—The sludge from the autoclaves where ammonia is liberated from cyanamid contains about 12 per cent of carbon in the form of graphite. It represents a richer source of graphite than most graphite ores and it should be possible to separate this valuable material from the sludge. There is enough of it to furnish all the graphite required for the manufacture of the carbide furnace electrodes, with a considerable surplus left over. This will represent a valuable by-product whose value could be charged off from the production cost of lime-nitrogen or ammonia.

Could all of the above improvements be realized, the cost of lime-nitrogen, already the cheapest source of fixed nitrogen, might well be considerably reduced, and that of the ammonia derived from it by as much or perhaps more.

There are even greater possibilities for the improvement of the Haber process of fixing nitrogen, for it is relatively so new. It will be too long a task to cover all of the possibilities, but a few of the more important ones are as follows:

1. *Removal of carbon monoxide.*—As has been pointed out already, the purification of the hydrogen from carbon monoxide is a matter of great difficulty. At present, even the catalyst which the Germans use for this purpose does not reduce the carbon monoxide content below 2 per cent, and as a consequence elaborate and expensive absorption towers, through which a copper solution is pumped, are required. It appears very probable that a catalyst operated at a much lower temperature than those now in use, and hence giving a negligible concentration of carbon monoxide, could be prepared. This could at one stroke reduce the cost of the ammonia by approximately a cent a pound.

2. *Improved absorption of carbon dioxide.*—The carbon dioxide also formed in the manufacture of the hydrogen is at present removed from the compressed gas by means of water. Owing to the slight solubility of carbon dioxide, large quantities of water are required, and this is not only a direct expense, but it also involves a considerable expense for compression. It appears certain that research will disclose a more economical method of carbon-dioxide absorption.

3. *An improved ammonia catalyst.*—The German catalyst for the formation of ammonia appears to be easily the best so far discovered. It is important that this catalyst be promptly equaled and indeed surpassed. To equal it should not be particularly difficult, as considerable information regarding the actual catalyst used by the Germans is available, and some progress in this direction has already been made. To exceed it will presumably not be easy, and the only hopeful course will be to study the problem from a fundamental point of view, endeavoring to understand the actual function of the catalyst in this reaction. The importance of even a slight improvement is, however, great. Thus, if a catalyst could be secured which would function satisfactorily at a temperature only 50 degrees lower than that now required, a several-fold increase in ammonia content would result. This would mean that the pressure in the circulating system could be considerably reduced and the cost of operation, maintenance, and installation considerably lessened.

4. *Improved ammonia absorption.*—The removal of the ammonia from the high-pressure system is now a matter of much expense and difficulty. Either expensive refrigeration of the circulating gases is resorted to, or they are passed through complicated absorption towers, filled with running and cooled water. It appears quite possible that by the use of suitable solutions rather than water, or possibly using solid absorbents, this removal could be effected much more cheaply and simply.

Finally, there are urgent problems connected with the war-time utilization of the Muscle Shoals plants which demand investigation. Thus, one of the important products of the plants is nitric acid, required for the manufacture of high explosives at powder plants. This acid, because of its very corrosive nature, is difficult to ship. It can be dissolved in concentrated sulphuric acid and the mixture shipped in tank cars, but this is objectionable for several reasons, and it appears much wiser to convert the acid into sodium nitrate and ship this as a solid substance. This, too, is the procedure followed by the Germans under similar circumstances. However, this process has never been carried out in this country, so it is important that it be studied carefully and at once. Such a process would be of interest only to the Government, and we can not expect, therefore, that private firms will undertake its solution. There will be excellent facilities for working out this problem if the Government operates the Muscle Shoals plants.

In conclusion, perhaps nothing I can say will emphasize my contention more than to cite how important the Germans considered and still do consider research and investigation on the fixation of nitrogen. The first Haber plant built at Ludwigshaven was moved in 1913 to Oppau. It already had the very considerable output of 20 or 30 tons a day, and the Germans had had several years' experience in its operation. In spite of this fact, when the plant at Oppau was further enlarged in 1914 the largest and finest of the new buildings constructed was the research laboratory. It is 300 feet long, over 100 feet wide, five stories high and is devoted entirely to research.

In August, 1919, when we were there, the plant was not in operation, but there were still some 75 chemists engaged in research in this building. We were informed that during the war 250 chemists were at work there on research problems, and this did not include control chemists housed elsewhere. In other words, in this factory alone, with the process complete and in successful operation, the Germans were and still are continuing an aggressive program of research far greater than even we propose.

In the above discussion, gentlemen, I believe I have demonstrated that there are a multitude of urgent problems on the fixation of nitrogen which demand study. These studies and investigations must be made, if we are to compete with foreign countries, and particularly Germany, in this industry, and we must compete, for we can not afford to be dependent on foreign sources of supply for this fundamental necessity.

If we are to compete we must be masters of the subject; the only way to do this is to study and practice. This study and practice must be on a practical scale, and if it is to be successful must be backed by resources which only the Government can command. The first step in this study is the operation by the Government of the plants at Muscle Shoals.

Senator WADSWORTH. Mr. Roberts, have you put into the records any notes as to the situation in which the Government would find itself in the manufacture of cyanamid in connection with the American Cyanamid Co., which owns the patent?

Mr. ROBERTS. We have not put it in yet. Mr. Glasgow has a letter, which we will have read, a little later, which covers this. But the point is this: We have to run under the contract; the contract requires that we pay a certain royalty to the American Cyanamid Co., which is set forth in Mr. Glasgow's letter, and there is also an operating fee to the Air Nitrates Corporation, which is likewise set forth in the letter. On cyanamid there is a $2.30 royalty, and $2.25 operating fee, per ton, making a total of $4.55. In the case of nitrate of ammonia, it is $5.11 royalty, and $5 operating fee or $10.11. For the sulphate of ammonia it is $2.62 for royalty to the American Cyanamid Co. and $2.56 as operating fee to the Air Nitrates Corporation, which makes $5.18.

Senator McNARY. What would that sell for a ton? What is it worth, commercially, per ton?

Mr. ROBERTS. The sale price, as we have it here, is cyanamid, at $37.50, and sulphate of ammonia, at $65, and nitrate of ammonia, at $95.

Now, I should say this; On June 1, 1921, these royalties will have to be settled by arbitration; that is arranged for in the contract. The operating fee ceases. I do not believe that the royalties will be anything like they are in this contract, which we will have to pay up to that time.

Senator SMITH of South Carolina. The contract runs on to 1921?

Mr. ROBERTS. For these royalties specifically, and after that the royalties are to be for the life of the patents. They are to be arbitrated. Now, when we come to arbitration I do not believe that any set of arbitrators are going to give those people any such royalties, due to the fact that the royalties are supposed to be on super earnings, not upon ordinary earnings, and therefore we would have to have an ordinary earning of 6 or 8 per cent on our actual investment—on what the plants could be built for to-day, and as we do not make but 5 per cent on $58,000,000, there would not be very much left for royalties.

Senator WADSWORTH. That is an assumption, of course.

Mr. ROBERTS. That is an assumption. Anyway, we leave it to the arbitrators.

Senator WADSWORTH. What is the life of the patent?

Mr. ROBERTS. They run out all the way from 1924 to 1931. I do not think that the base patent of the cyanamid production is to-day worth anything, since it has been more than 17 years it has been known as a product.

Senator SMITH of South Carolina. So that taking the base, any improvement that might be made upon it, would not be under their control, if we take the base patent, and then had some patented process, or some improvement that was not an infringement on their later improvement.

Mr. **Roberts**. Well, as they built their plants they naturally incorporated in those plants those methods that they had patented, so far as that goes.

Senator **Smith** of South Carolina. Mr. Secretary, do I understand you to say that under one of your contracts in the Ordnance Department that if we make any improvement of their process we are to pay them a royalty on it?

Mr. **Roberts**. That is the General Chemical Co. contract.

Secretary **Baker**. There is no royalty in that, I believe.

Mr. **Roberts**. About $5 per ton of nitrogen; it is not very much.

Senator **Smith** of South Carolina. But the operating expense, the price of operating, that is constant; that is as long as you use their process.

Mr. **Roberts**. Until 1921 only; it expires then.

The **Chairman**. You said a moment ago that you did not believe that a certain one of these patents was worth anything. What do you mean?

Mr. **Roberts**. I said that the basic patent of the process has been known for more than 17 years.

The **Chairman**. If there are no further questions, who is the next gentleman to be heard?

Mr. **Roberts**. Maj. Gaillard, who has been with the Nitrate Division since it started, and has worked on all of these problems with us. He has made a study of the demand and supply of nitrogen products in commerce, the most complete and accurate statement ever gotten up on this subject, I believe.

The **Chairman**. We will be glad to hear him.

STATEMENT OF MAJ. D. P. GAILLARD, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Maj. **Gaillard**. I have prepared a statement, going at some length into this matter, to go into the record. I am now simply going to read extracts from that statement, give certain summaries, and will show you some charts that we have had prepared that will show these things graphically.

The **Chairman**. Very well, you may proceed.

Maj. **Gaillard** (reading):

Balance of Consumption and Supply of Inorganic Nitrogen in the United States and Necessity for Fixing Atmospheric Nitrogen.

General.—In the past 20 years more than three-quarters of the total inorganic or mineral nitrogen consumed in this country has been imported. It is my purpose here to estimate as accurately as possible the probable peace-time consumption of nitrogen in this country in the next 10 years, and to determine just what part of this consumption can reasonably be expected to come from the domestic production of nitrogen, and what part must come from the imports of foreign nitrogen.

Nitrogen will be required in the future principally to supply the consumption within this country and to a much lesser extent it will be exported to other nitrogen-consuming countries. The peace-time domestic consumption is for two principal purposes—to supply the demands of agriculture, and to supply the demands of industry, for nitrogen as you have been told, is not only an essential plant food and, therefore, a constituent of all complete commercial fertilizers, but it is also used extensively in several of the most important and fundamental chemical industries of the country.

The domestic supply of nitrogen in the future will come first from the recovery of nitrogen contained in bituminous coal when the coal is coked either in by-product coke-ovens or in gas retorts, and second from the nitrogen of the air transformed into usable form in fixed-nitrogen plants.

The amount by which this domestic supply fails to meet the consumption must be made up, as has been the case in the past, by importing nitrogen into this country, probably in the form of nitrate of soda from the natural nitrate deposits in Chile.

The probable future consumption of nitrogen in agriculture and in industries will first be considered, then the probable domestic supply from the coking of coal and the nitrogen-fixation plants will be taken up, and then can be determined to what extent this country will be self-sustaining in nitrogen and to what extent we will be dependent upon foreign countries.

In forecasting the future consumption and supply it is necessary to study not only the conditions that have prevailed in the past, but also to consider carefully any factors tending to make future conditions differ from past conditions. And when studying past conditions, since all the uses of nitrogen have been steadily increasing, it is not satisfactory to consider merely one or two years and study conditions during those years, but the general trend of growth from year to year over as many years as possible must also be studied.

In order to show this growth clearly and to keep this statement as free as possible from somewhat complex statistics, there has been prepared a series of charts which show graphically the actual consumption and supply of nitrogen in the past 20 years and the estimated consumption in the next 10 years for each of the broader divisions of consumption and supply, and each of these charts will be discussed later.

Statistics are avilable giving the total supply of nitrogen in this country during each of the last 20 years. As to just how this nitrogen was used equally reliable information is not available, but a fairly accurate estimate can be made for each year. There are sometimes appreciable stocks of nitrogeneous materials carried over from one year to be used up in the next. In this study, however, the consumption for each year has been assumed to equal the supply for that year. If in one year by this method the consumption is too high, the next year it will be correspondingly too low, and any relatively small errors so introduced will neutralize themselves in studying the general trend of consumption over a period of years.

NITROGEN CONSUMED IN AGRICULTURE.

General.—The first use of nitrogen that will be considered is the use in fertilizers. Nitrogen, together with phosphorus and potassium, is essential to the growth of plant life, and all fertilizers contain one or more of these elements, and most fertilizers contain all three. Of these, nitrogen is as important as any and in the proportion ordinarily used is the most expensive of the three.

In the United States it is customary for the fertilizer manufacturer to mix, in various given proportions, materials containing these three elements, which are bagged and sold to the farmer as mixed fertilizer, probably 80 per cent of the fertilizer used in this country being in the form of mixed goods.

The nitrogen in fertilizers is derived from two classes of materials—organic, or animal and vegetable materials, and inorganic, or mineral and chemical materials. The most important organic materials used are cottonseed meal (containing some 7 per cent nitrogen) and animal tankage, a waste product of the meat-packing industry (containing some 8 per cent nitrogen).

Senator Smith of South Carolina. For what other purpose is tankage used outside of fertilizer?

Maj. Gaillard. It is used largely for feed. This last year probably more than half of the total tankage went into feed and less than half into fertilizer.

Senator Smith of South Carolina. And that use as a feed is still increasing?

Maj. Gaillard. Yes; and the price is now up, it is up with feed stuffs; its price is fixed as a feed, and not as a fertilizer.

Senator Smith of South Carolina. Cottonseed meal is bringing more per ton than nitrate of soda, that has just double the amount of nitrate in it.

Maj. Gaillard. Yes, sir; that is because it is in demand in the feed market, and the nitrate of soda is not. [Continuing reading:]

Other organic materials used are garbage, fish scrap, hair, horns, scrap leather, etc., the nitrogen contained in these materials varying from 15 to 5 per cent. The inorganic materials used are Chilean nitrate (containing 15.6 per cent nitrogen) and sulphate of ammonia—the form in which nitrogen is usually recovered from the coke ovens (containing 20.6 per cent nitrogen) and to a much lesser extent cyanamid, one of the forms in which nitrogen is fixed from the atmosphere (containing about 19½ per cent nitrogen) together with a very small amount of other chemicals.

In 1917, according to statistics gathered by the Department of Agriculture, a little less than half of the total nitrogen in mixed fertilizers was furnished by inorganic materials, Chilean nitrate supplying about three-fifths of this, sulphate of ammonia about one-third and miscellaneous materials the remainder. If we include the Chilean nitrate sold for separate application to the soil, about 60 per cent of the nitrogen sold for fertilizer would come from inorganic materials. Of the organic nitrogen about equal quantities were furnished by cottonseed meal and tankage, the two together supplying about 60 per cent of the organic nitrogen.

Use of fertilizer in the past.—Commercial fertilizers first began to be used in this country some 50 years ago and their use has increased steadily since that time. By 1904 the value of the fertilizers sold was ten times their value in 1869. From 1904 to 1914 the growth was very much more rapid, the value of the products in 1914 being three times, and the total tonnage of fertilizers manufactured being approximately two and a half times the amounts in 1904.

Statistics available on the manufacture of fertilizer in the United States in the past are as follows:

[From United States census statistics.]

Year.	Tons of fertilizer manufactured.	Per cent of increase for 5-year period.	Per cent of increase for 10-year period.	Per cent of increase for 15-year period.
1899	2,887,000			
1904	3,592,000	24		
1909	5,618,000	57	94	
1914	8,432,000	50	135	192

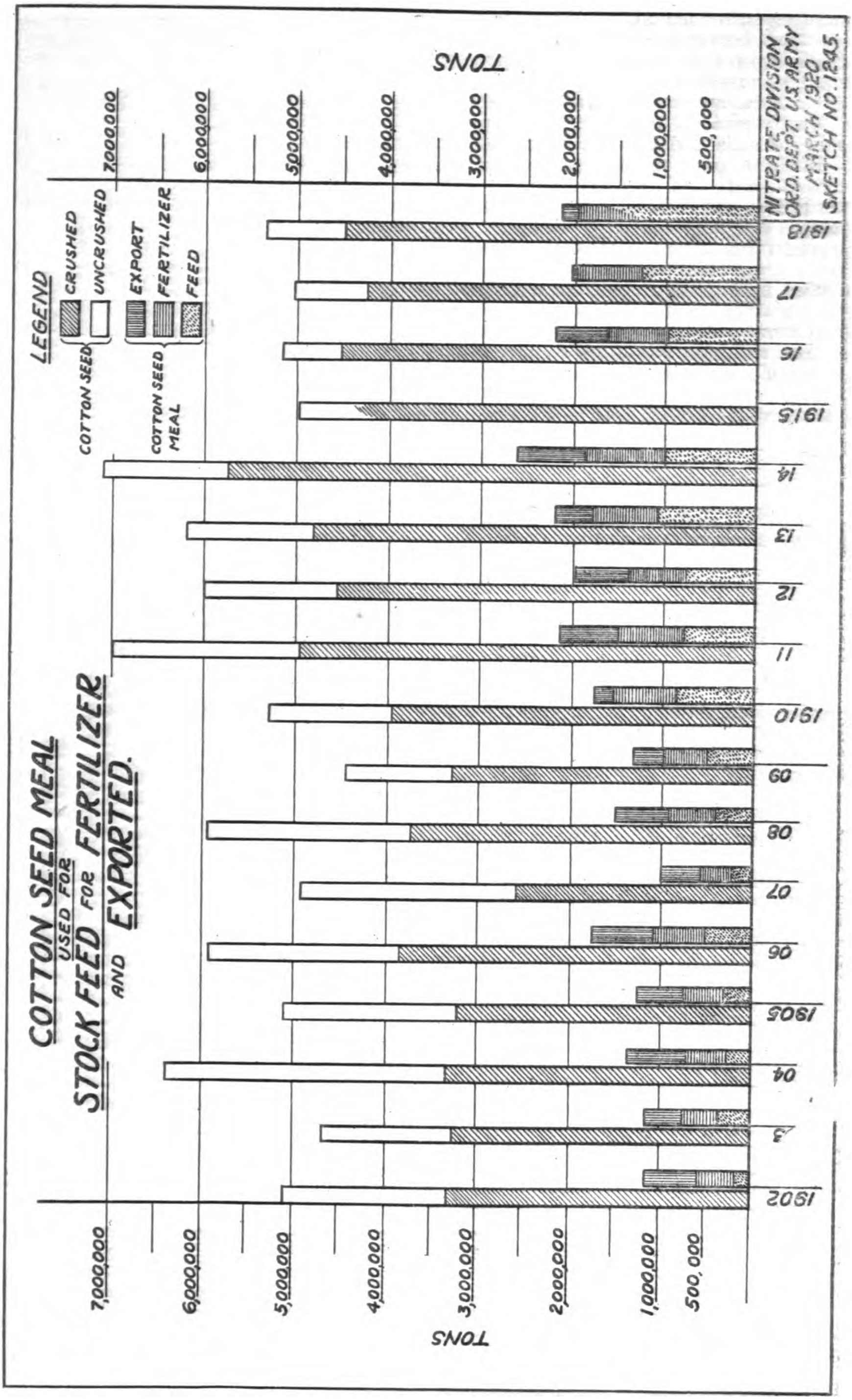
It has been noted that in the 10 years prior to 1914 the use of commercial fertilizers more than doubled, the rate of growth in each 5-year period being substantially the same. In 1915, owing to the influence of the war, with the abnormally low price received for the cotton crop and the demoralization of the fertilizer industry, the consumption of fertilizer decreased very considerably. There was a still further slight decrease in 1916, but since that time the consumption has been increasing at approximately the rate that prevailed from 1909 to 1914. Exact figures for 1919 are not yet available, but it is estimated that the consumption last year was in the neighborhood of 7,500,000 tons, and while the 1920 consumption may actually be smaller than that last year, it will be due to the extreme shortage that has prevailed and is prevailing in all fertilizer materials, a shortage that has caused the abnormally high price of fertilizer materials now obtaining. It is evident that the demand for fertilizer is not being met and the present consumption is a matter of present supply rather than of present demand.

Although the South has been and is the principal user of fertilizer, in the last few years, having taken some 60 per cent of the total production, the Middle West has shown the largest rate of growth from 1910 to 1914 and since 1916, and now uses over 10 per cent of the total. New England, which uses about 6 per cent, has shown the next most rapid growth, and the Middle Atlantic States, using a little less than 20 per cent, have a growth slightly greater than that of the South.

Need of fertilizers.—This very rapid growth in the use of fertilizers in the United States is only repeating what has taken place in Europe. As the land has become depleted, the crop yields have fallen off and to bring the soil back to its original fertility it has been necessary to supply fertilizer to make up the deficiency. This tendency was first felt in the South and the East, as the soil there had been under cultivation for a longer period, and was particularly marked in the South where conditions made rotation of crops very difficult and where cotton is usually planted on the same land year after year. A large part of the soils in the corn belt of the Middle West are now or will soon become depleted in nitrogen and the use of fertilizers in that section must inevitably increase even faster in the future than in the past.

If the price of fertilizer were low enough, there is for practical purposes almost no limit to the amount that could be advantageously used. It has been estimated by Dr. Lipman, director of the New Jersey Agricultural Experiment Station, that the annual loss of nitrogen from all land under cultivation in the United States which is

PLATE 4.


COTTON SEED MEAL USED FOR STOCK FEED FOR FERTILIZER AND EXPORTED.
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NITRATE DIVISION
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SKETCH NO. 1245.

not replaced by manure, by the nitrogen supplied by plowing under leguminous crops, by atmospheric precipitation in the form of rain and snow and by the present use of commercial fertilizer, amounts to between three and four million tons of nitrogen, to replace all of which would take from fifteen to twenty million tons of sulphate of ammonia, or from one hundred and fifty to two hundred million tons of ordinary commercial mixed fertilizer.

It would not pay now or in the immediate future to use fertilizer to any such extent on all of the land under cultivation, but these huge figures represent the upper limit to the use of nitrogen in fertilizer, and show how far from that limit the present consumption is.

At present it will pay to use fertilizer in many cases where it did not pay before the war; the value of land in most agricultural sections of the country has increased very considerably; the cost of farm labor has increased even more rapidly; and the value of the farm products in general is much higher than before the war. The use of fertilizer which causes a greater production per unit of land and per unit of farm labor, provided this fertilizer can be secured at a reasonable price, must therefore inevitably increase, and, assuming that a sufficient supply is available, it is entirely reasonable to assume that it will increase even faster than it did before the war.

Future use of fertilizers.—From 1899 to 1914 the consumption of fertilizer in the country practically tripled, an increase substantially equivalent to an increase each year of 7½ per cent over the previous year. The growth during the last 5 years of this period was at an even greater rate, and since the slump in 1915 and 1916 the recovery has been practically at this same rate. It is therefore conservative to assume, in view of the factors mentioned before, which favor the increasing use of fertilizer even more than was the case before the war, that this growth will continue at the prewar rate of 7½ per cent per year at least until 1924. This would give a total fertilizer consumption for 1924 of 10,500,000 tons, a figure which, it is to be noted, is only about 25 per cent higher than the figure as actually reported by the census statistics for 1914—10 years earlier.

The rate of growth from 1924 to 1930 has been assumed to continue uniformly at a somewhat slower rate, an increase of a little less than 800,000 tons a year, which gives for 1930 a total consumption of 15,200,000 tons.

Increasing use of inorganic nitrogen in fertilizers.—All of the organic nitrogenous materials are the by-products of other industries, principally the meat-packing and cottonseed-oil industries. Although there has been a steady growth in these industries in the last 20 years, this growth has not been nearly so great as the growth in the consumption of fertilizer. Moreover, there has been a steadily increasing use both of cottonseed meal and animal tankage for feeding purposes, this use increasing especially rapidly in the last or three four years. The net result of this has been to make available for fertilizer use a slowly increasing amount of organic nitrogen up to three or four years ago. since which time there has been a considerable decrease—a decrease especially marked in the last year. During the past few months, garbage tankage from cities like Pittsburgh and Baltimore, which was formerly used exclusively for fertilizer purposes, has been entirely withdrawn for feeding purposes.

It is to be noted that at present the price of cottonseed meal is approximately the same as corn meal, about three-fourths of that of oatmeal, about two-thirds that of wheat flour. At these relative prices, it will naturally be evident why cottonseed meal is going into feed rather than into fertilizer.

Figures compiled by the Department of Agriculture show that in 1917 and 1918 about half of the high-grade animal tankage was being used for feed and about two-thirds of the cottonseed meal. Since then this proportion has undoubtedly increased. That these materials are now primarily feeds and only secondarily fertilizers is shown further by the course of their prices in the last year or so, during which time their prices have been controlled by the feedstuff market rather than by the prices of their competitive fertilizer nitrogenous materials, Chilean nitrate, and sulphate of ammonia.

To show graphically just how cottonseed meal has been diverted from use as fertilizer to use as stock feed during the last 16 years, this chart (pl. 4) has been prepared. The tall left-hand column for each year represents the total tonnage of cottonseed, the shaded part representing that part of the seed which was crushed and yielded cottonseed oil and cottonseed meal. The shorter right-hand column for each year represents the total tonnage of cottonseed meal, the bottom part representing that part of the meal used for stock feed, the middle part that used for fertilizers, and the top part that exported. A study of this chart will show first that, broadly speaking, there has been but little increase during this period in the total tonnage of seed, the increase in the total amount of meal being due to the crushing of a gradually increasing proportion of the seed each year, and to better recovery methods. It will be noted how greatly the use of meal as a feed has been growing, at first absorbing all the increase in production, then cutting into exports, and finally into the use as fertilizer.

And very much the same thing has been happening in the case of tankage.

Some figures may help to show just how these tendencies have affected the proportions of organic and inorganic nitrogen used in fertilizers. In 1899 statistics indicate that about five-sixths of the nitrogen in mixed fertilizers, together with that used separately, came from organic nitrogenous materials; in 1904 about three-quarters; in 1909 slightly over half; and in 1914 slightly under a half, and in 1919 somewhat over a third. It is estimated that in 1924 this proportion will not be more than a fifth, and in 1929 not more than a tenth, as in 1924 there will be available not more than 45,000 tons of nitrogen from organic sources, about 60 per cent of the amount available in 1917, and in 1929 not more than 30,000 tons of nitrogen, about 40 per cent of the amount available in 1917.

Future use of inorganic nitrogen.—This next chart (pl. 5) has been prepared showing for every fifth year since 1899 the total tonnage of fertilizer, the total tonnage of nitrogen in this fertilizer, and the relative proportions of organic and inorganic nitrogen. It is evident from this that inorganic nitrogen in 1929, for instance, must supply not only all nitrogen requirements in excess of those at present existing, but must replace more than half of the organic nitrogen now being used. And this explains why the growth in the use of inorganic nitrogen in fertilizers in the future will be at a much greater rate than the growth in the use of fertilizers.

It will be noted that this chart shows a consumption for fertilizer of 172,000 tons of inorganic nitrogen in 1924, and 269,000 tons in 1929, equivalent respectively to 830,000 tons and 1,300,000 tons of sulphate of ammonia, or 985,000 long tons and 1,540,000 long tons of Chilean nitrate.

The next chart (pl. 6) is the first of a series all plotted to the same scale and similarly arranged, and shows for each of the last 20 and the next 10 years the total consumption of inorganic nitrogen, and the consumption of inorganic nitrogen for agriculture in the form of fertilizers. It will be noted that the columns representing this use are the same as those shown on the previous chart. This chart shows not only the consumption in agriculture but shows just what part this is of the total consumption and gives an idea of its relative importance.

NITROGEN CONSUMED IN INDUSTRIES.

Uses of nitrogen in industry.—The next use of nitrogen that will be considered is its use in the industries of the country. In the chemical industries of the country, in which is included the manufacture of domestic explosives, nitrogen plays a very important part. This nitrogen is consumed in two forms, as nitric acid made from Chilean nitrate and ammonia derived from the gas works and the by-product coke ovens. At present about two-thirds of the nitrogen is consumed in the form of nitrate and about one-third in the form of ammonia.

Somewhat more than half of the nitrate used goes into the manufacture of industrial explosives, such as dynamite, blasting powder, etc., which are used not only for practically all mining and quarrying operations but to a rapidly increasing extent for road building, clearing land, digging ditches, and other labor-saving purposes. Somewhat less than half of the nitrate goes into other chemical industries, principally the production of the several nitrocellulose products which include artificial leather, now almost universally used for automobile upholstery, photographic films, imitation ivory, and all forms of celluloid. It is also used to some extent in the glass industry.

Of the ammonia approximately one-quarter is used in connection with the operation of cold-storage plants and for the manufacture of artificial ice, about one-third is used in the quantity production of staple chemicals, principally soda ash, ammonium chloride and sodium cyanide, about one-eighth goes into the explosive industry, principally for the manufacture of ammonium nitrate, and the remainder is used for miscellaneous purposes including the manufacture of household ammonia.

Senator **Smith** of South Carolina. Well, the sources of nitrogen for the arts and sciences, that has always been principally from the inorganic?

Maj. **Gaillard**. Yes, sir; almost entirely so. [Continuing reading:]

Estimates of past consumption.—In estimating the amount of Chilean nitrate used in the industries in each of the several years, the estimated amount consumed in fertilizers has been deducted from the imports for that year and the remainder taken to be nitrate used in the industries. Of course, during the World War the military consumption has also been deducted.

PLATE 5.

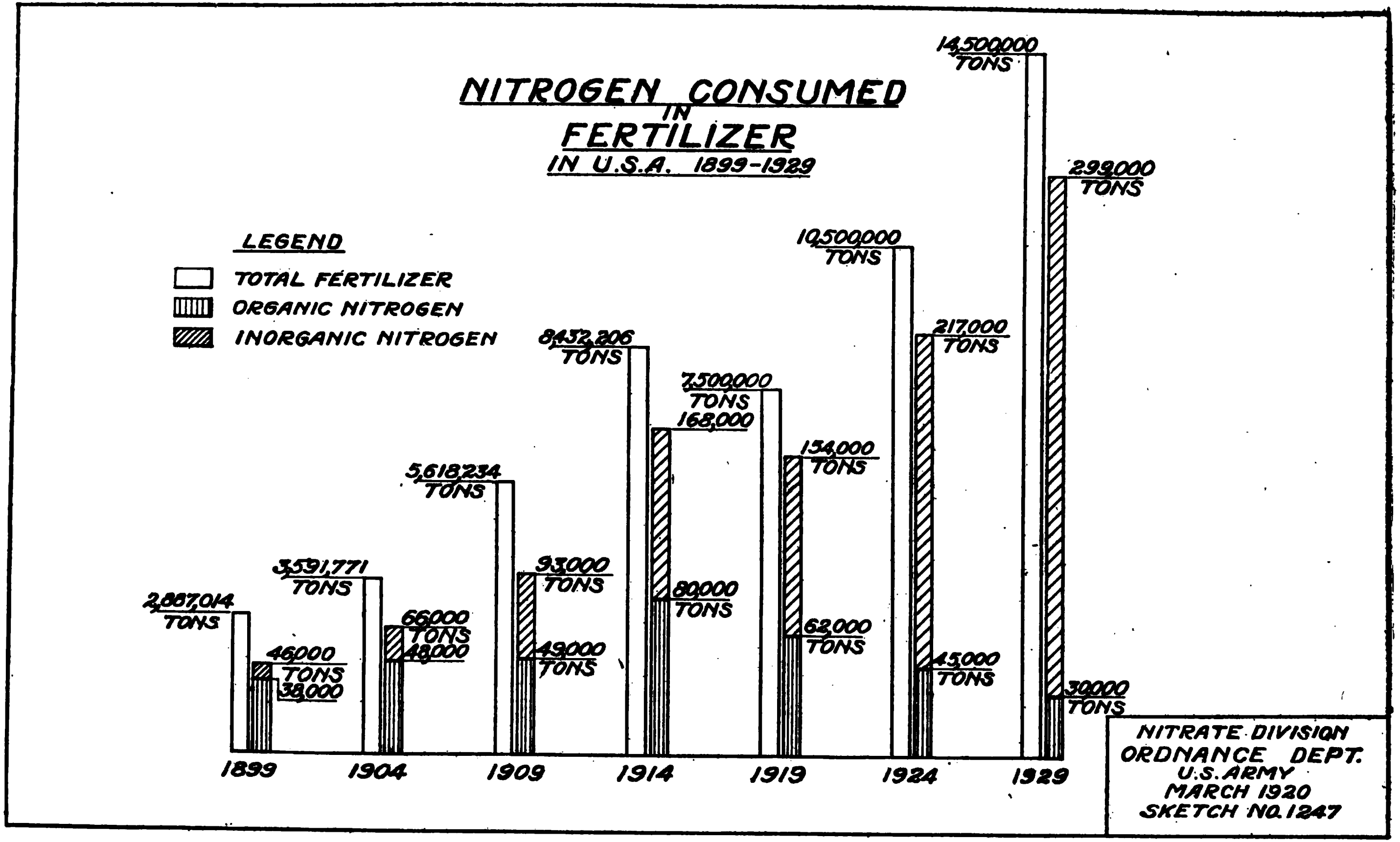
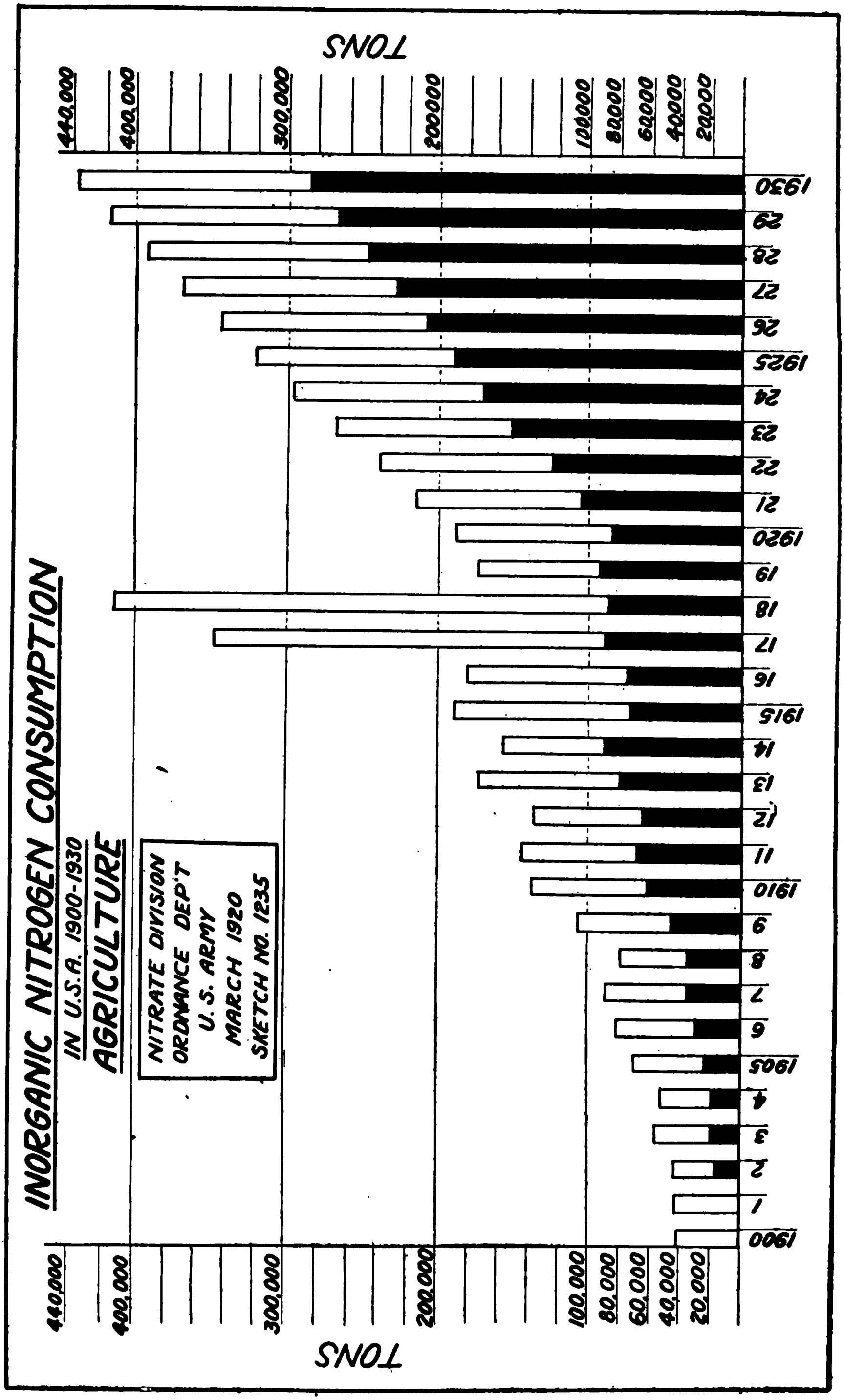
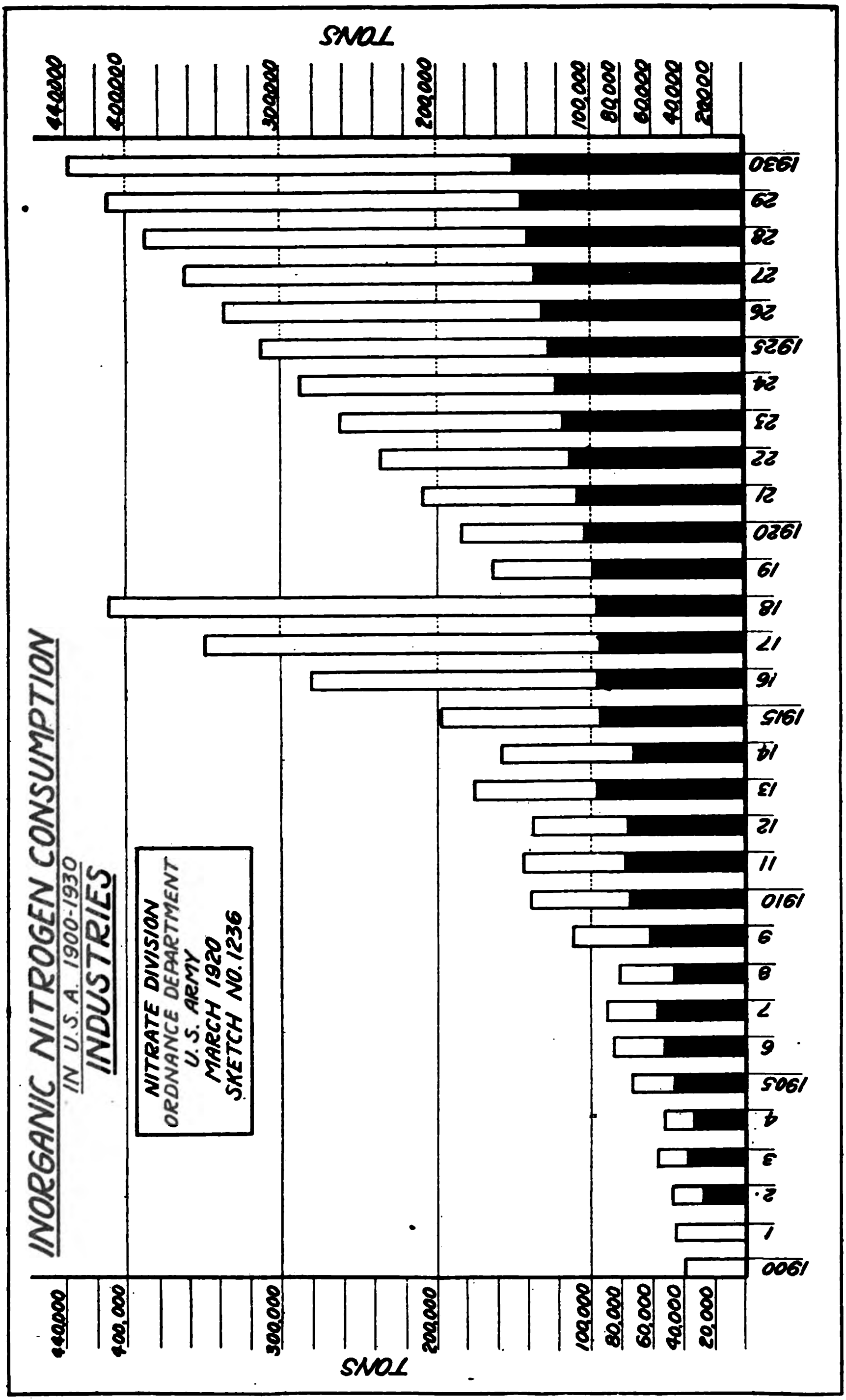

NITROGEN CONSUMED IN FERTILIZER
IN U.S.A. 1899-1929
LEGEND
TOTAL FERTILIZER
ORGANIC NITROGEN
INORGANIC NITROGEN
2,887,014 TONS
46000 TONS
38,000
3,591,771 TONS
66000 TONS
48,000
5,618,234 TONS
93,000 TONS
49,000 TONS
8,452,206 TONS
168,000
80,000 TONS
7,500,000 TONS
154,000 TONS
62,000 TONS
10,500,000 TONS
217,000 TONS
45,000 TONS
14,500,000 TONS
299,000 TONS
30,000 TONS
1899
1904
1909
1914
1919
1924
1929
NITRATE DIVISION
ORDNANCE DEPT.
U.S. ARMY
MARCH 1920
SKETCH NO. 1247

PLATE 6.


INORGANIC NITROGEN CONSUMPTION
IN U.S.A. 1900-1930
AGRICULTURE

NITRATE DIVISION
ORDNANCE DEP'T
U.S. ARMY
MARCH 1920
SKETCH NO. 1235

PLATE 7.


INORGANIC NITROGEN CONSUMPTION
IN U.S.A. 1900-1930
INDUSTRIES
NITRATE DIVISION
ORDNANCE DEPARTMENT
U.S. ARMY
MARCH 1920
SKETCH NO. 1236
TONS
440,000
400,000
300,000
200,000
100,000
80,000
60,000
40,000
20,000
1900
1
2
3
4
1905
6
7
8
9
1910
11
12
13
14
1915
16
17
18
19
1920
21
22
23
24
1925
26
27
28
29
1930

In the case of ammonia, for most of the years statistics are available from the United States Geological Survey, giving the total production of ammonia from by-product coke ovens and giving that part of the production which is in the form of sulphate of ammonia. The difference between these two plus the entire ammonia output of the gas works has been taken to be that portion of the ammonia consumed in chemical industries. The relatively small part of the ammonia production from gas works which goes into the manufacture of sulphate of ammonia may be assumed, without serious error, to balance that small part of the sulphate going into the chemical industry.

The figures thus determined show that there was from 1902 to 1914 a steadily increasing use of both nitrate and ammonia in industry, the use of nitrate increasing each year by approximately 20,000 short tons (17,850 long tons), containing 3,125 tons of nitrogen, and the use of ammonia increasing each year by approximately 2,125 tons, containing 1,750 tons of nitrogen. The normalized consumption of ammonia in industries during 1919 is estimated at 42,500 tons, containing 35,000 tons of nitrogen, a figure obtained by assuming the prewar growth to have continued to 1919. In the case of nitrate, however, the normalized consumption in 1919 has been taken to be 400,000 short tons of Chilean nitrate—containing 62,500 tons of nitrogen—approximately the normalized consumption in 1914, and somewhat greater than the actual consumption in 1913. By normalized consumption is meant the consumption assuming that in 1919 the nitrogen-using industries were normally busy. The total consumption in industries of both nitrate and ammonia estimated for 1919 is then 97,500 tons of nitrogen.

The use of both nitrate and ammonia has been assumed to continue to increase from 1919 to 1930 at the prewar rate of about 4,875 tons of nitrogen a year. It is believed that this is a very conservative estimate as this rate of increase at the beginning of the period amounts to only 5 per cent and at the end of the period to only 3½ per cent a year. On this basis there would be consumed in industry in 1924 approximately 500,000 tons of Chilean nitrate and 53,000 tons of ammonia, together containing 120,000 tons of nitrogen, and in 1930 the estimated consumption would be 600,000 short tons of Chilean nitrate and 64,000 tons of ammonia, together containing 150,000 tons of nitrogen.

The next chart (pl. 7), similar to the last, shows graphically by the black part of each column the year by year consumption in industries, and shows again just what part of the total nitrogen consumption this industrial use is. It will be noted how very conservative the estimated growth for the next 10 years is, when compared to the actual growth during the past 20 years.

In the above discussion it has been assumed that in the future the requirements for ammonia nitrogen and for nitrate nitrogen are distinct, but developments during the war have shown that the conversion of ammonia nitrogen to nitrate nitrogen is entirely practicable and should ammonia be relatively more plentiful than nitrate and, therefore, its price appreciably lower, there is no question but that a considerable part of the requirements for nitrate nitrogen would be supplied by the conversion of ammonia nitrogen.

NITROGEN CONSUMED IN MILITARY EXPLOSIVES.

Prior to the outbreak of the World War, the total consumption of nitrogen in this country for military explosives increased from some few hundred tons in 1900 to between one and two thousand tons in 1914. Exact statistics on the consumption during this period are not readily obtainable and since the use of nitrogen for this purpose is such a very small part of the total consumption, exact figures are not necessary.

In the latter part of 1915, the manufacture of explosives for the Allies began and from then on until the armistice, in 1918, the production of military explosives increased at a tremendous rate in this country. In 1918, the year of maximum consumption, somewhat less than 150,000 tons of nitrogen, it is estimated, were actually consumed in the manufacture of military explosives. At the same time a military reserve stock of Chilean nitrate was slowly being built up with the object of ultimately accumulating a sufficient quantity to last for six months should all imports be cut off. And a smaller stock of ammonium sulphate was being accumulated for the manufacture of ammonium nitrate. As a result, at the end of 1918 approximately 80,000 tons of nitrogen were on hand in the form of these stocks of material. In other words, the accumulation of these essential reserves together with the actual consumption required in 1918 in the neighborhood of 230,000 tons of nitrogen, equivalent to more than 1,300,000 long tons of Chilean nitrate, a quantity of nitrogen more than a third greater than the consumption for all purposes in the highest year before the World War.

The future consumption of nitrogen in military explosives so long as the United States is not involved in war will be but little larger than was the case before the war, and in fact, it may actually be even less owing to the large amounts of powder and explosives now in storage. In any event the peace time consumption of nitrogen for military explosives will be a negligible part of the total consumption.

So long, however, as this country is so largely dependent on imported nitrogen, conditions will be similar in case of a future war, and nitrogen will have to be supplied not only to meet the actual consumption, but to establish a sufficient reserve to safeguard against any enemy completely cutting off all imports.

This next chart (pl. 8), similar to the two previous ones, shows by the black part of the columns the consumption each year for military explosives, and shows how this consumption, insignificant in time of peace, becomes not only the most important but the greatest part of the total consumption in time of war.

This covers the three principal uses of nitrogen—for fertilizer, for industries, and for military purposes.

Senator SMITH of South Carolina. Did I understand, from one of the charts that you have just shown that the use of nitrogen for explosives in 1918 surpasses all the other usages put together for the year?

Maj. GAILLARD. It not only exceeds all other uses for 1918 when these other uses were restricted, but it exceeds them for any year up to the present. [Continuing reading:]

NITROGEN EXPORTED.

In the past but little inorganic nitrogen has been exported, as this country itself has been such a heavy importer of nitrogen. A large part of the little inorganic nitrogen exported was contained in mixed fertilizers manufactured here.

However, since the practical cessation of sulphate exports from Europe, and particularly in the last year, the United States has been exporting a fairly considerable amount of sulphate of ammonia to the West Indies and to the Far East. Although no statistics are available, it has been estimated that the exports last year of inorganic nitrogen may have amounted to nearly 10 per cent of the total domestic consumption.

The question as to what may be expected as to the exports of nitrogen from this country in the future is most uncertain, and in this study no allowance will be made for any future exports. There undoubtedly will be some exports, and it is very desirable that there be exports both from a commercial and a military point of view; but as these will increase the requirements for nitrogen in the United States and only serve to accentuate the deficiency of the domestic supply, they will not be included in balancing the total consumption and supply.

NITROGEN RECOVERED FROM COAL.

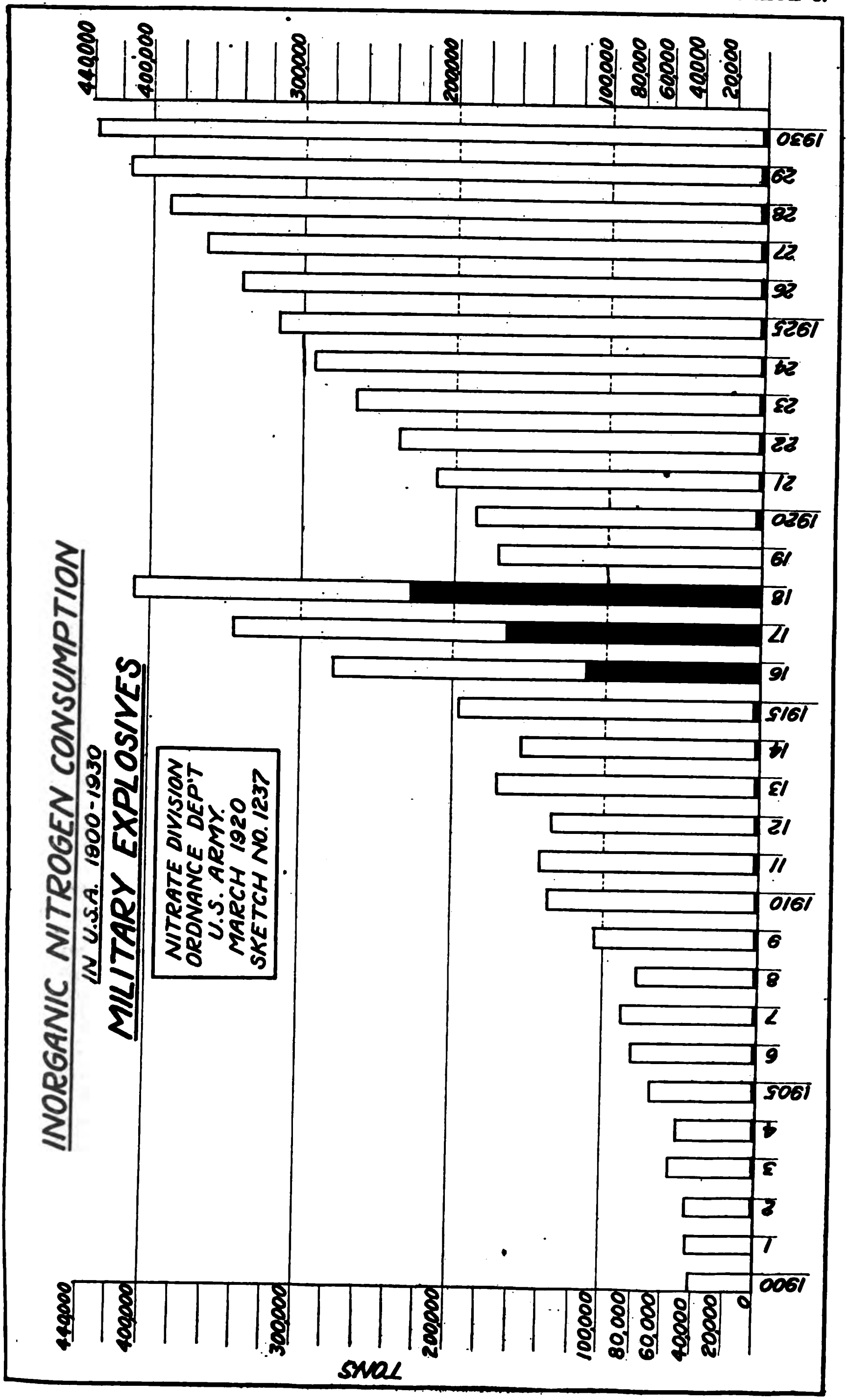
General.—Bituminous coal, such as is used for the manufacture of coke and the production of coal gas, contains from 1 to 2 per cent of combined nitrogen. During the coking process, part of this nitrogen is driven off in the form of ammonia. In the beehive or original type of coke oven, this ammonia escapes with the other gas and is lost. It was in order to recover this ammonia, as well as the gas and the other products of the distillation of coal, that the by-product coke oven came into existence. The gaseous ammonia is recovered from the coke oven gas either by absorption in water, forming crude ammonia liquor; or absorption in sulphuric acid, forming sulphate of ammonia.

It is evident, therefore, that ammonia is a by-product of the coking of coal either in by-product coke ovens or in the manufacture of coal gas. But the great bulk of coke is used in the blast furnaces in the production of pig iron, and therefore, in order to study intelligently the past production of ammonia from by-product coke ovens and to forecast the future production, it is necessary to study the pig-iron industry, upon which this production depends. Before doing this, however, it will be advisable to consider briefly the past history of by-product coke production in the United States.

Senator SMITH of South Carolina. What per cent of the production of coke in this country saves its by-products?

Maj. GAILLARD. Last year somewhat less than 60 per cent. That is a greater percentage than ever before, due to the fact that there was diminution in the coke requirements, and the beehive produc-

PLATE 8.


INORGANIC NITROGEN CONSUMPTION
IN U.S.A. 1900-1930
MILITARY EXPLOSIVES
NITRATE DIVISION
ORDNANCE DEP'T
U.S. ARMY.
MARCH 1920
SKETCH NO. 1237
TONS
440000
400000
300000
200000
100000
80000
60000
40000
20000
0
1900
1
2
3
4
1905
6
7
8
9
1910
11
12
13
14
1915
16
17
18
19
1920
21
22
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1925
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29
1930

tion fell off much more than the by-product production. [Continuing reading:]

By-product coke production.—By-product coke ovens were first introduced in this country about 1893, but by 1902 the total coke production from this source was only 5 per cent of the total. There was a more or less constant growth to 1912, in which year about 25 per cent of the total coke was produced in by-product ovens. The consequence of this very rapid increase was a tendency toward an over-supply of by-products, and consequently the building of additional by-product ovens was checked somewhat until stimulated by the war. Since 1914 the increase has been abnormal, owing to the demand for the by-products in the manufacture of munitions. In 1917 and 1918, in order to secure an adequate supply of toluol, the basis of T. N. T., the Ordnance Department stimulated by special contracts the construction of many additional by-product ovens. The last of the ovens so constructed will not be completed until about the middle of 1920. As the result of this increase, in 1918 about 46 per cent of the total coke was produced in by-product ovens. In 1919 the demand for coke decreased very considerably, and while the production of by-product coke fell off 4 per cent from the 1918 figures, the production of beehive coke fell off 44 per cent from the figures for the previous year as the consequence of which the proportion of by-product coke produced in 1919 was 56 per cent.

The by-product ovens now in existence, together with those contracted for during the war, and now under construction and nearly completed, it is estimated can furnish a maximum coke production of 36,500,000 tons a year, or 64 per cent of the record high 1918 consumption; or 82 per cent of the 1919 consumption of coke, which, although considerably lower than that in 1918, has previously been exceeded in only three years, and equaled in one other year.

Beehive coke production.—These figures without further study might confirm the popularly held idea that the beehive ovens in this country are being replaced by by-product coke ovens, but this has not been the case. A study of the coke production statistics compiled by the United States Geological Survey shows that in the last 15 years there has been no general decrease in the production of beehive coke, the average for the first 5 years, for the next 5 years, and for the last 5 years of this period being substantially the same. It is evident, then, that the by-product coke ovens in the last 15 years have been built to take care of the increase in the demands of the country for coke, but that considering the country as a whole, there has been no substitution whatever as yet of by-product ovens for beehive ovens.

Senator SMITH of South Carolina. Is the saving of ammonia as a by-product comparatively cheap?

Maj. GAILLARD. Yes, sir, in connection with the other by-products. Of course, it would not pay to put up by-product coke ovens for the coke and ammonia alone.

Senator SMITH of South Carolina. The thing I was driving at was, if, with the cheapening of nitrogen from any other source, would it have a tendency to cause them to disregard it, or let it go to waste in the production of coke?

Maj. GAILLARD. No, sir.

Senator SMITH of South Carolina. But as it goes on in combination with other by-products, then it would be constant perhaps?

Maj. GAILLARD. Yes, sir.

Senator SMITH of South Carolina. What is the total production of ammonia from that source, in tons?

Maj. GAILLARD. The statement going into the record will give that to you. We have assumed that by 1930 about 70 per cent of the total coke production will come from by-product coke ovens.

Senator SMITH of South Carolina. What number of tons of cyanamid is used in this country from the Canadian plant?

Maj. GAILLARD. Practically their entire output; about thirteen or fourteen thousand tons of nitrogen a year.

Senator SMITH of South Carolina. About what per cent of our total nitrogen consumption do we import now?

Maj. GAILLARD. This year we will import about half. Last month we imported more nitrogen than we had ever imported before in any single month before 1916, this notwithstanding the very great increase in domestic production since then.

Senator SMITH of South Carolina. That is largely accounted for by the fact that the other sources of ammonia that we have been using, tankage and meal, have been diverted to something else, and now we must import something to take its place.

Maj. GAILLARD (reading):

Future pig-iron production.—To intelligently forecast the future demand for coke it is necessary as has been stated before, to consider the probable growth in the pig-iron industry, a fundamental industry of the country and one reflecting so accurately the general business conditions that it is often used as a "barometer of industry." A study of the statistics of pig-iron production as reported by the United States Geological Survey shows a practically constant growth in the last 20 years, the annual increase averaging about 1¼ million gross tons per year. The industry has grown somewhat irregularly, periods of reduced production following every few years, periods of record production, but the growth given above represents the average growth during this period. If the normal growth of 1,250,000 tons per year had continued to 1920, it is estimted the consumption last year would have been in the neighborhood of 36,000,000 tons, instead of 30,500,000 tons as was actually the case.

During the war steel was to a very considerable extent cut off from nonessential industries, and a great amount of construction work was postponed. It is reasonable to assume that in the next few years the major part of these accumulated unfilled requirements must be met. On the other hand, it is unlikely that railroad requirements for steel—a very considerable part of the total requirements in past years—will be so great as previously.

In view of this it is believed that the most accurate estimate that can be made at this time is to assume that the production of pig iron in this country during the next few years will continue to increase at the average prewar rate of 1,250,000 tons per year. Under this assumption the pig-iron production in 1924 would be in the neighborhood of 43,000,000 tons, and in 1930 would be 50,500,000 tons.

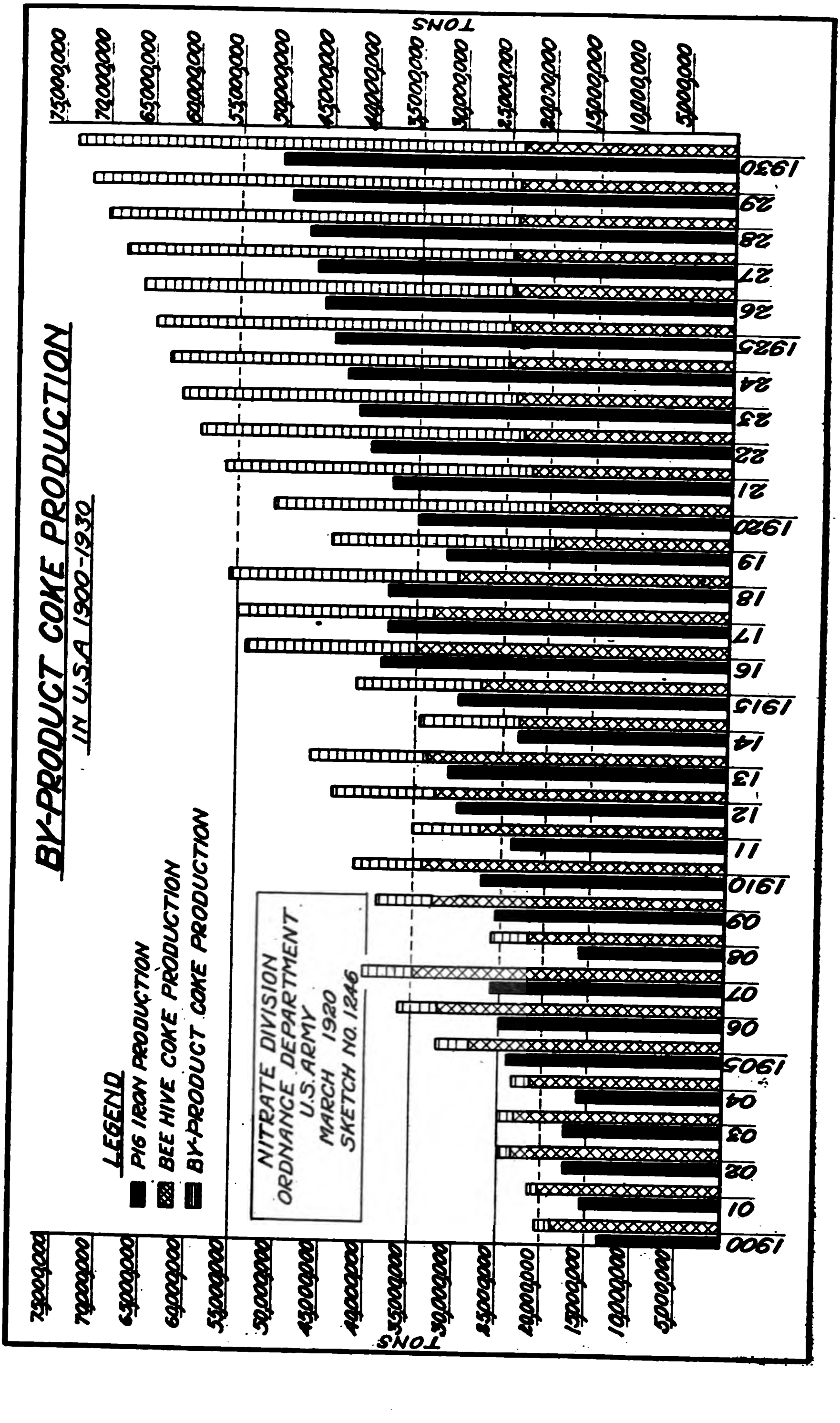
Future by-product coke production.—The coke required to produce 43,000,000 tons of pig iron, together with the amount of coke used for other purposes, would be, based on past experience, approximately 63,000,000 net tons. The by-product ovens now built and building can supply approximately 36,500,000 tons, or approximately 58 per cent of this—a greater proportion of by-product coke than there has ever been in the past, leaving if no new by-product ovens are constructed, a total of 26,500,000 tons to be furnished by beehive ovens. It is pertinent to note that this is only 89 per cent of the average beehive production for the past 15 years, and that the beehive production during these 15 years has fallen below this figure in only three years.

It is entirely possible that sooner or later by-product ovens will supply from two-thirds to three-quarters of the total coke production, but it is very unlikely that they will displace beehive ovens to any greater extent than this. The iron industry has always been a business of ups and downs, and consequently the coke requirements have fluctuated from year to year.

A study of the statistics shows in the last 15 years four cases in which the production of coke has fallen off very considerably from the previous year, the percentage of decrease ranging from 36 to 15 per cent of the production of the previous year and averaging for these four years, 25 per cent. A by-product oven once built must continue in operation if possible. Not only because it must carry much heavier fixed charges on capital invested than the cheaper beehive oven, but if shut down it must be partly reconstructed at considerable cost before placed in operation again. On the other hand, the simple beehive oven can be put into operation after an extensive period of idleness at comparatively small cost. Business considerations would therefore indicate that the maximum production to be expected from by-product ovens would be that production necessary to supply the minimum requirements, the difference between the minimum requirements and the maximum requirements—that is, the noncontinuous requirements—being taken care of by the cheaper and simpler beehive ovens. A study of the statistics of coke production from these two sources for the past few years will show very clearly how much less capable the by-product production is of fluctuating with the variable demand.

It is very unlikely, however, that in the next five years there will be any considerable number of new by-product ovens constructed. Not only is the cost of construction more than double the prewar cost, but the production of by-products from the coke ovens now built and building will be approximately three times that of the highest

PLATE 9.


BY-PRODUCT COKE PRODUCTION
IN U.S.A. 1900-1930
LEGEND
■ PIG IRON PRODUCTION
▨ BEE HIVE COKE PRODUCTION
▤ BY-PRODUCT COKE PRODUCTION
NITRATE DIVISION
ORDNANCE DEPARTMENT
U.S. ARMY
MARCH 1920
SKETCH NO. 1246
TONS
5,000,000
10,000,000
15,000,000
20,000,000
25,000,000
30,000,000
35,000,000
40,000,000
45,000,000
50,000,000
55,000,000
60,000,000
65,000,000
70,000,000
75,000,000
1900
01
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1905
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prewar year. Under these conditions, with the extensive world-wide demand for capital, it is difficult to see how any considerable amount of money will be invested in the by-product coke oven industry, abnormally stimulated during the war in order to further increase in a period of high costs, an already plentiful supply of most of the by-products.

It is possible there will, however, be certain individual by-product coke ovens constructed where local conditions may be peculiarly advantageous. It is believed, however, that an allowance for the year 1924 of 1,500,000 tons of coke from by-product ovens other than those now built and building, is a very liberal one.

We, therefore, have for 1924, a maximum possible production of 36,500,000 tons of coke from by-product coke ovens now built and building, and an additional allowance of 1,500,000 tons of coke from ovens which may come into production during this period, making an estimated total by-product coke production in 1924 of 38,000,000 tons or 60 per cent of the total coke production.

In 1930 to manufacture the estimated production of 50,500,000 tons of pig iron and to meet the other requirements, there will be required approximately 73,500,000 tons of coke. It is estimated that by-product ovens will supply approximately 50,000,000 tons, or 68 per cent of this, leaving 23,500,000 tons to be furnished by beehive ovens. These figures compare with 38,000,000 tons and 25,000,000 tons estimated from these two sources for 1924. In other words, it is assumed that not only will all the increase in coke requirements be furnished from by-product ovens, but also that by-product ovens will replace the beehive ovens operating in 1924 to the extent of 1,500,000 tons of coke.

This chart (pl. 9) shows for each year the pig-iron production in the smaller solid black columns to the left, and the production of beehive and by-product coke shown, respectively, by the lower and upper parts of the right-hand columns. It shows clearly how the total coke production varies with the pig-iron production; it shows how heretofore the beehive ovens have about held their own, the by-product ovens supplying the increase in the production, and it shows that the estimate as to future production of pig iron and coke are consistent with past experience, and it shows how much smaller the future production from beehive ovens, and how very much greater the future production from by-product ovens is than their respective production in the past.

Yield of ammonia.—Statistics collected by the United States Geological Survey prior to the war indicated, for the by-product coke ovens all over the country, an average yield of 5 pounds of ammonia per ton of coal coked. During the war, owing to the use of inferior coals and the lower efficiencies during forced production, this yield decreased to slightly less than 4½ pounds. It is believed, however, that prewar conditions can be equaled again and therefore in these estimates an average recovery of 5 pounds of ammonia per ton of coal coked equivalent to 7 pounds of ammonia per ton of coke produced is assumed. It is believed that this figure is liberal, and, while in certain cases the recovery may run as high as 6½ pounds per ton of coal, in other cases it runs very materially less than 5 pounds.

Total ammonia from by-product ovens.—On the basis of 7 pounds of ammonia recovered per ton of coke produced, we would have an ammonia recovery for 1924 of 133,750 tons of ammonia, equivalent to 535,000 tons of ammonium sulphate, and in 1930, 175,000 tons of ammonia equivalent to 700,000 tons of ammonium sulphate.

Ammonia recovered in manufacture of coal gas.—In the manufacture of coal gas, coal is coked in retorts differing somewhat from by-product coke ovens, but the methods of recovery are very much the same. Exact figures for the several past years in the production of ammonia from this source are not obtainable, but as only a relatively small proportion of the total ammonia recovered comes from gas works, and this proportion is constantly growing less, a reasonable approximation will be sufficient for our purposes.

In 1915 the United States Geological Survey reported a total production from gas works of 12,980 tons of ammonia and in 1917 of 11,440 tons. These are the only two recent years for which exact statistics are available, but estimates of production during the last eight years show an annual production varying from a minimum of somewhat over 10,000 tons to a maximum of 13,000 tons. The high year was 1915, since when the production has apparently decreased slightly. It is believed that an allowance for 1924 of 15,000 tons of ammonia and in 1930 of 18,750 tons of ammonia from gas works will be ample in view of the experience in the last few years. Further it is believed that the extremely small amount of ammonia from bone carbonizing works can be included in these figures without error.

Total ammonia recovered from coal.—We thus have for 1924 as the maximum amount of ammonia that can reasonably be expected to be recovered from coal, a total of 148,750 tons, equivalent to 595,000 tons of sulphate of ammonia, or 122,500 tons of nitrogen and in 1930 a total of 193,750 tons of ammonia, equivalent to 775,000 tons of sulphate of ammonia, or 159,500 tons of nitrogen.

In the next chart (pl. 10) the black part of the column represents for each year the supply of nitrogen from the coking of coal in by-product coke ovens and gas retorts, the total height of the column, as before, representing the total consumption or supply of nitrogen. It will be noted how this source of supply rapidly increased during the war so that this year it will furnish about half of the total consumption, but it will also be noted that the consumption will grow faster than this source of supply so that by 1930 it will furnish only a little over a third of the total estimated consumption.

NITROGEN FROM THE FIXATION OF ATMOSPHERIC NITROGEN.

Commercial plants.—In the past there has been almost no quantity fixation of atmospheric nitrogen within the limits of the United States. For a few years a small arc process plant operated in North Carolina and more recently another small arc process plant has been operating in the State of Washington. Some other experimental and development installations operated on a very small scale, but the aggregate supply from all these sources has been a negligible factor in the country's total supply of nitrogen.

Government plants.—During the war, United States nitrate plant No. 1, at Sheffield, Ala., using the General Chemical Co.'s modification of the Haber process, and United States nitrate Plant No. 2, at Muscle Shoals, Ala., using the cyanamid process, were practically completed.

Experimental operation had started at plant No. 1, but the process is not yet developed, and considerable further study of the fundamentals of the process and modification of the equipment are necessary before regular production can be secured from this plant.

Plant No. 2 was tested and showed conclusively that it could produce fixed nitrogen at its rated capacity—approximately 45,000 tons per year—at reasonable cost. Altogether No. 2 plant produced some 600 tons of nitrogen in 1918 and some 700 tons of nitrogen in 1919. The production from No. 1 plant was negligible.

Future production from Government plants.—If the operation of the two plants for the production of nitrogenous materials to be used in the manufacture of fertilizer is authorized as recommended by the War Department, it is estimated that the production from this source will be approximately 45,000 tons of nitrogen in 1924, gradually increasing to 55,000 tons of nitrogen in 1930.

Future production from privately owned plants.—Within the last few months the General Chemical Co. and the Semet-Solvay Co. have joined forces for the further development of the Haber process in this country. It is most unlikely that there will be any considerable tonnage production from this source by 1924, as it is doubtful if the process will be developed on a manufacturing basis before that time. If this process is worked out, which is still very much of a question, it will gradually enter as a production factor, and in order to be liberal we have assumed that by 1930 some 25,000 tons of nitrogen may be secured from this new source. To secure this production will necessitate the investment of some $20,000,000, and it is not believed that this industry will develop any faster than this.

The next two charts (Plates 11 and 12) show, as before, balanced against the total supply of nitrogen for each year the estimated production from the Government-owned fixed nitrogen plants and from the privately owned fixed nitrogen plants. It will be noted what a relatively small part of the total consumption can be supplied from the Government plants.

NITROGEN FROM IMPORTS.

Past imports.—In the past 20 years more than three-quarters of the nitrogen consumed in this country has been imported, principally from Chile in the form of nitrate of soda, usually known as Chilean nitrate.

For some years before the World War, fairly considerable amounts of sulphate of ammonia were imported, for the most part from England, at their maximum furnishing somewhat less than one-fifth of the total nitrogen imported; but during the war England needed this nitrogen at home and imports from this source fell to almost nothing. The plant of the American Cyanamid Co. at Niagara Falls, Canada, for the fixation of atmospheric nitrogen entered into production in 1910 and imports of cyanamid from this plant have steadily increased since that date, but they furnished only a small fraction of the total nitrogen imported. The main reliance of this country, however, in the past has been the importation of Chilean nitrate and the abnormal war demands were met almost entirely by expansion of this source of supply.

Future imports.—A study of the nitrogen situation indicates that the requirements of the country will in the future, as in the past, first absorb the domestic production. This will be the case, as domestic nitrogen can always undersell any imported nitrogen. It is evident that this is true with the nitrogen from the by-product coke ovens and

PLATE 10.

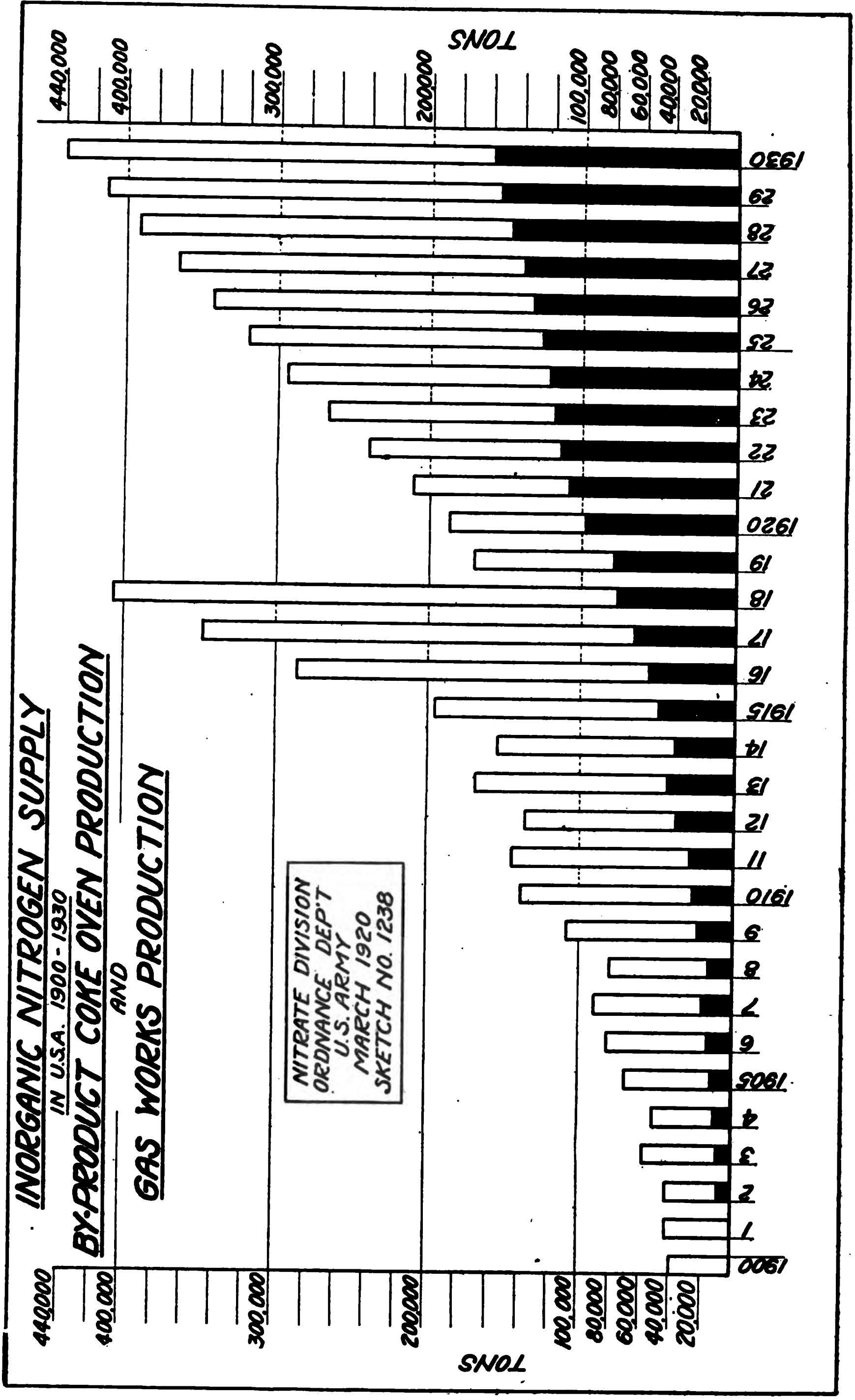

INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
BY-PRODUCT COKE OVEN PRODUCTION
AND
GAS WORKS PRODUCTION
NITRATE DIVISION
ORDNANCE DEP'T
U.S. ARMY
MARCH 1920
SKETCH NO. 1238
TONS
440,000
400,000
300,000
200,000
100,000
80,000
60,000
40,000
20,000
1900
1
2
3
4
1905
6
7
8
9
1910
11
12
13
14
1915
16
17
18
19
1920
21
22
23
24
25
26
27
28
29
1930

PLATE 11.

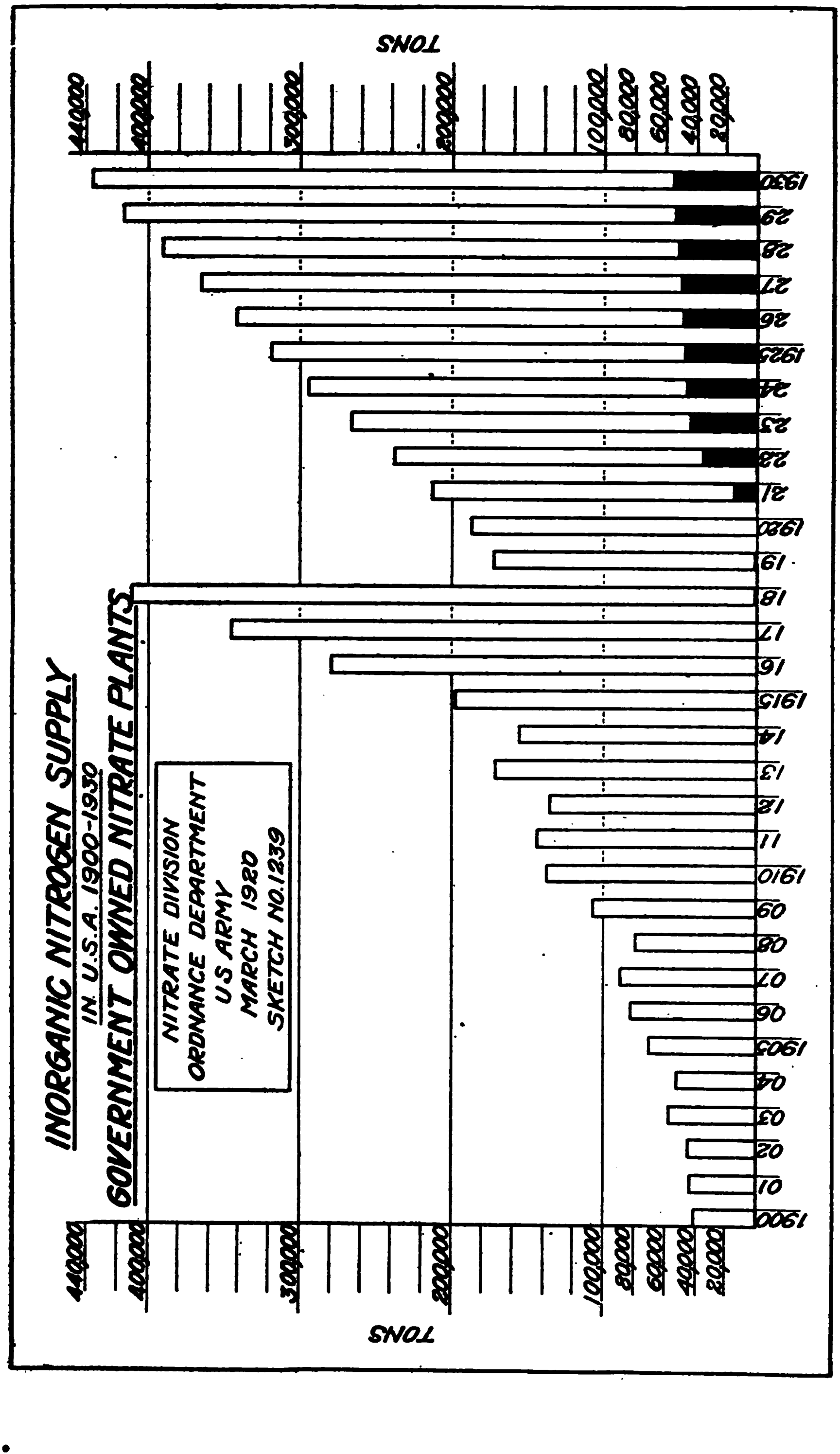
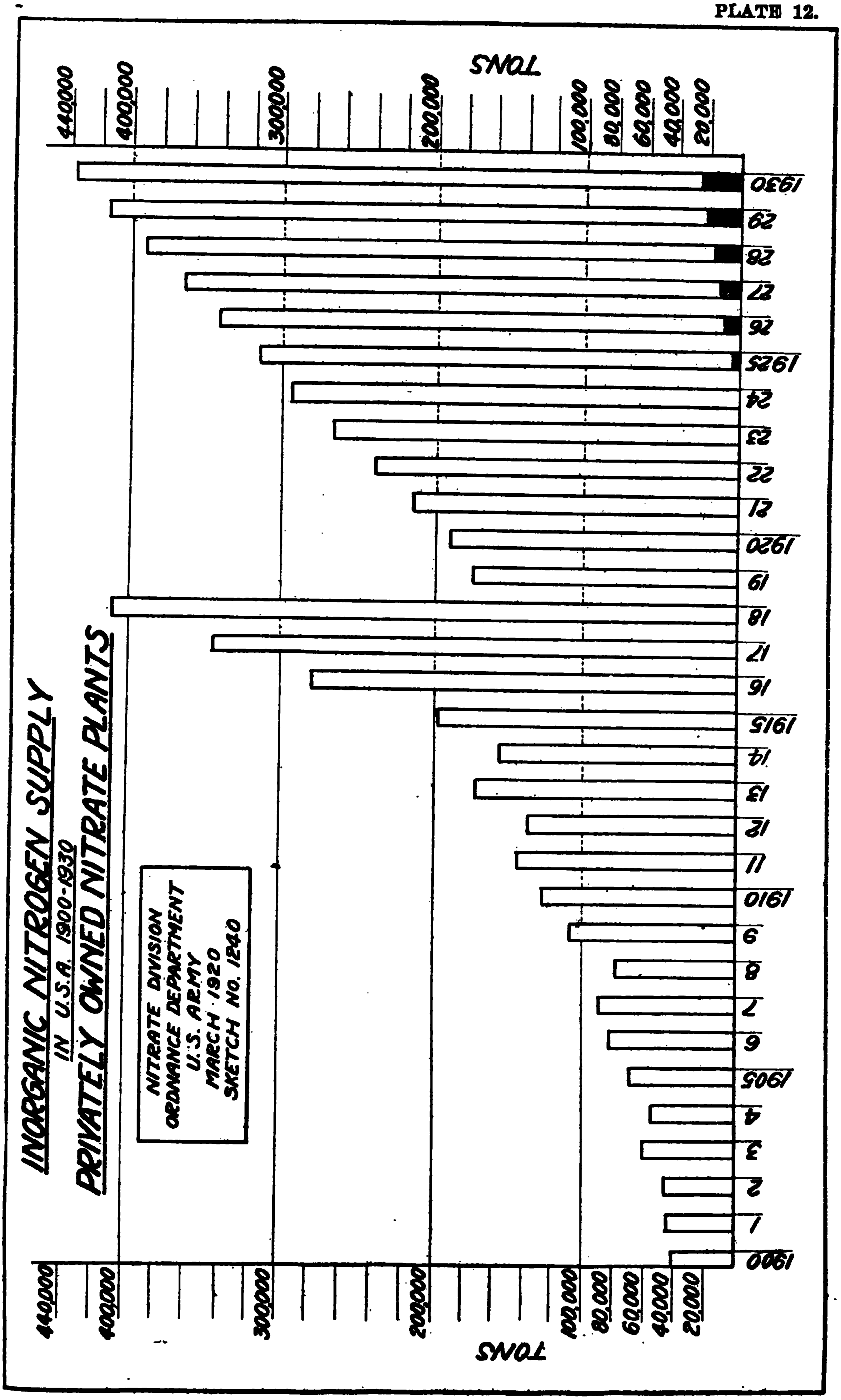

INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
GOVERNMENT OWNED NITRATE PLANTS
NITRATE DIVISION
ORDNANCE DEPARTMENT
US ARMY
MARCH 1920
SKETCH NO.1239
TONS
440,000
400,000
300,000
200,000
100,000
80,000
60,000
40,000
20,000
1900
01
02
03
04
1905
06
07
08
09
1910
11
12
13
14
1915
16
17
18
19
1920
21
22
23
24
1925
26
27
28
29
1930

PLATE 12.


INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
PRIVATELY OWNED NITRATE PLANTS
NITRATE DIVISION
ORDNANCE DEPARTMENT
U.S. ARMY
MARCH 1920
SKETCH NO. 1240
TONS
440,000
400,000
300,000
200,000
100,000
80,000
60,000
40,000
20,000
1900
1
2
3
4
1905
6
7
8
9
1910
11
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16
17
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19
1920
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23
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1925
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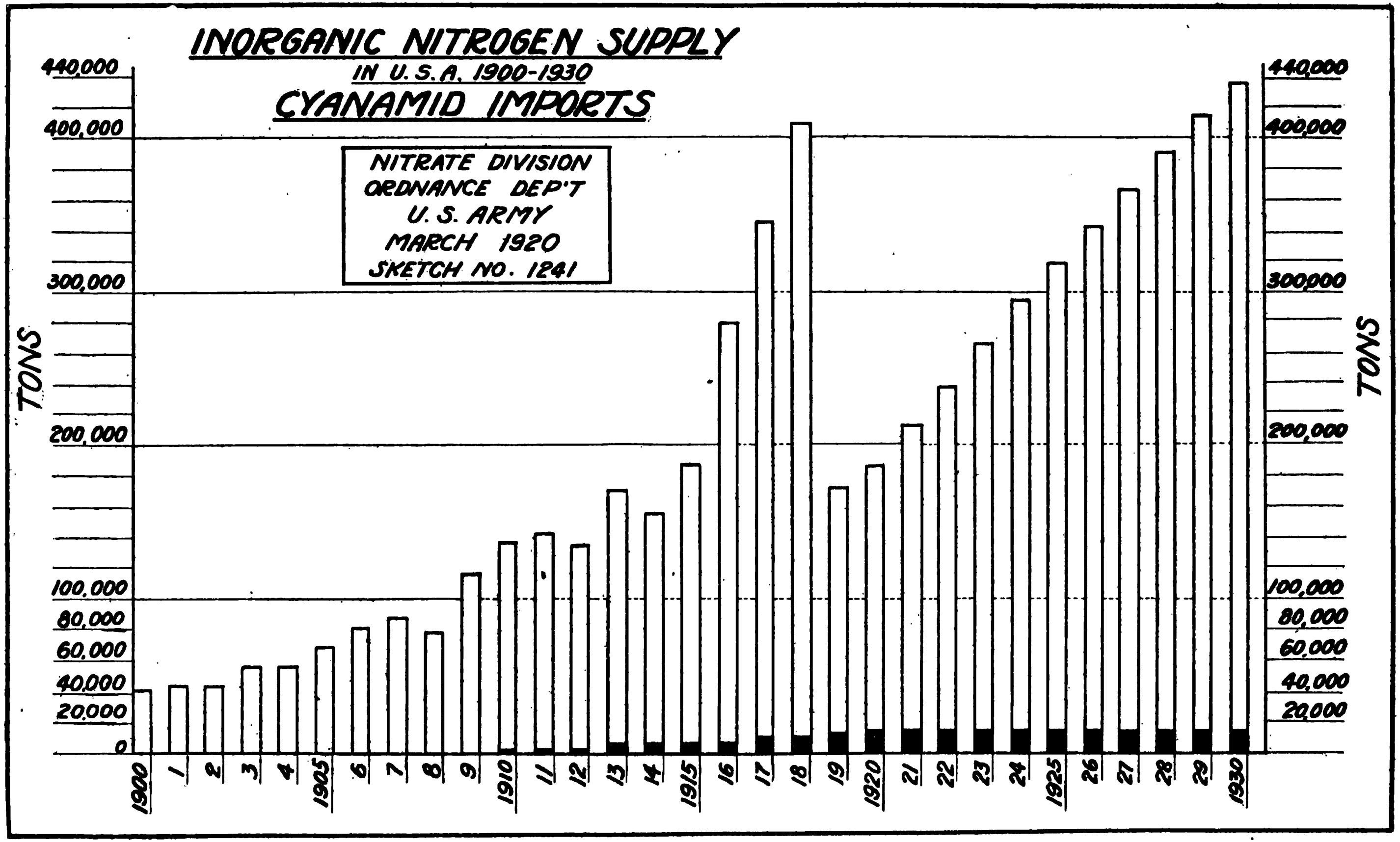
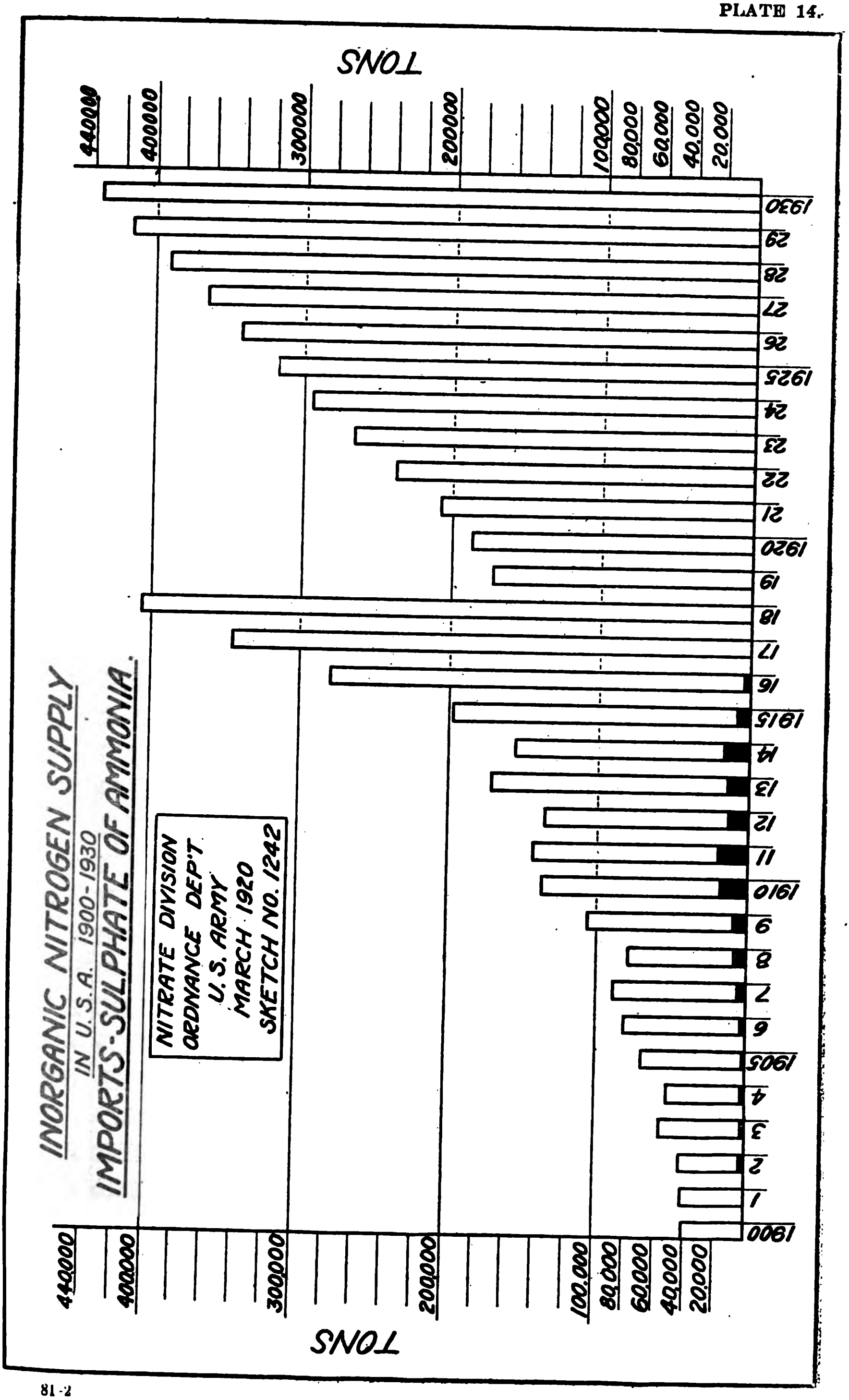
27
28
29
1930



INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
CYANAMID IMPORTS

NITRATE DIVISION
ORDNANCE DEP'T
U. S. ARMY
MARCH 1920
SKETCH NO. 1241

PLATE 14.


INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
IMPORTS-SULPHATE OF AMMONIA.
NITRATE DIVISION
ORDNANCE DEP'T.
U.S. ARMY
MARCH 1920
SKETCH NO. 1242
TONS
440000
400000
300000
200000
100000
80000
60000
40000
20000
1900
1
2
3
4
1905
6
7
8
9
1910
11
12
13
14
1915
16
17
18
19
1920
21
22
23
24
1925
26
27
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29
1930
TONS
440000
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300000
200000
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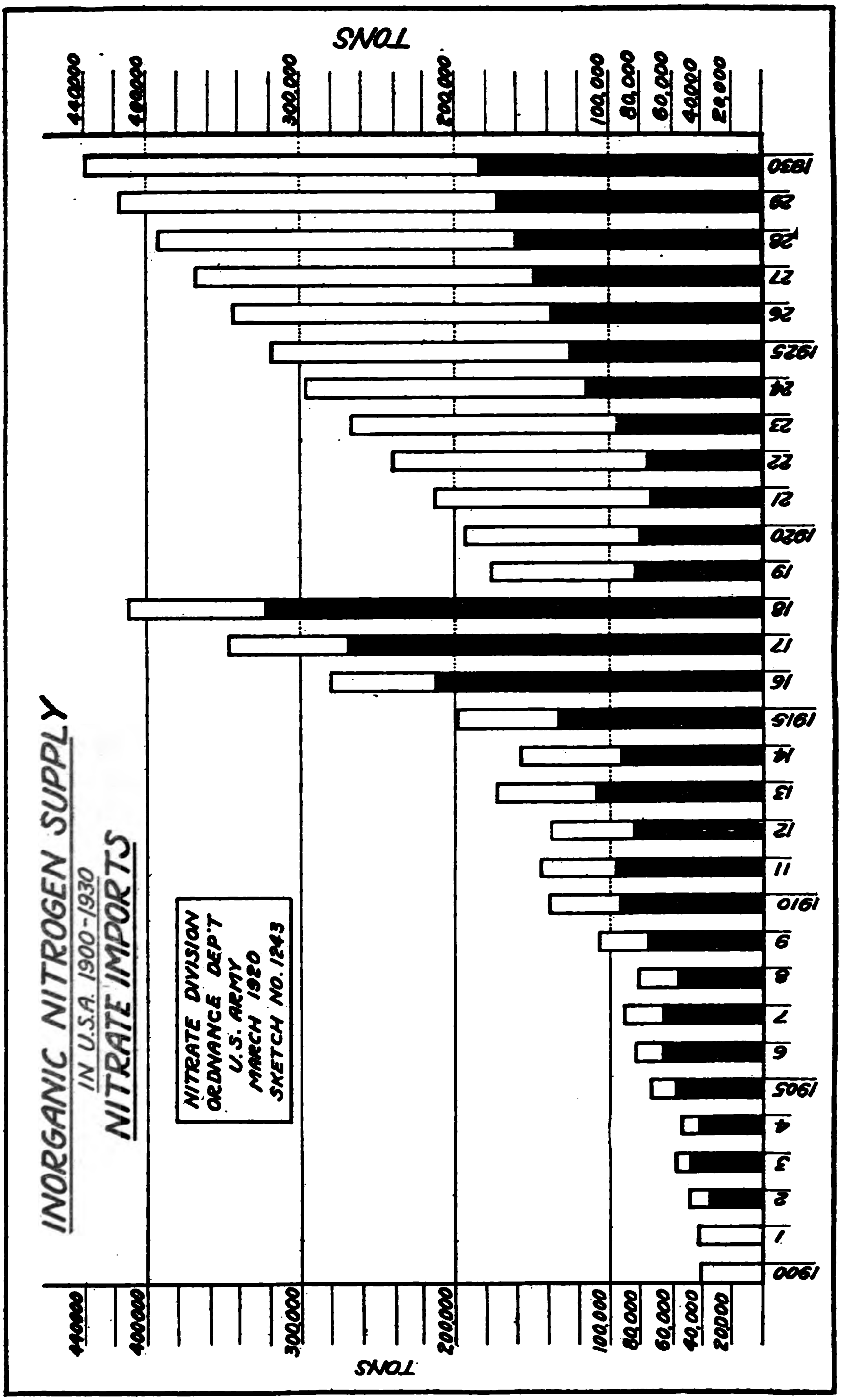
80000
60000
40000
20000

81-2



INORGANIC NITROGEN SUPPLY
IN U.S.A. 1900-1930
NITRATE IMPORTS

NITRATE DIVISION
ORDNANCE DEP'T
U.S. ARMY
MARCH 1920
SKETCH NO. 1243

gas works, where the cost of production, as is the case with any by-product, is largely a matter of bookkeeping. This is also true in the case of the Government nitrate plants, which can fix and sell nitrogen at an operating expense less than any probable selling price of imported nitrogen in the next 10 or 20 years. The nitrogen which it has been estimated will be produced in the future from privately owned fixed nitrogen plants will certainly not materialize unless private capital is convinced that nitrogen from this source can undersell, if necessary, any imported nitrogen. In other words, under the conditions that will prevail in the future, when the consumption will be considerably greater than the domestic supply, the price will be controlled by the cost of the imported nitrogen necessary to supply the deficiency in the domestic production and the imports will just be sufficient to meet this deficiency.

Whether most of this imported nitrogen will be in the form of Chilean nitrate or whether some nitrogen may be obtained either from the European by-product coke ovens or from European fixation plants is immaterial. It is believed, however, that most of it, over and above the relatively small amount contained in the cyanamid imported from Canada, will be furnished by Chilean nitrate, as has been the case in the past.

The imports of nitrogen, other than those of Canadian cyanamid, which it is estimated will furnish some 15,000 tons of nitrogen, necessary to supply the estimated deficiency of domestic production in 1924 amounts to 112,000 tons of nitrogen, equivalent to approximately 640,000 long tons of Chilean nitrate, and in 1930 to 183,500 tons of nitrogen, or slightly more than 1,000,000 long tons of Chilean nitrate.

The next three charts (Plates 13, 14, and 15) similar to those already shown, give the imports of cyanamid from Canada, the imports of sulphate of ammonia from Europe, and the imports of nitrate of soda from Chile. It will be seen how relatively insignificant the other two imports are compared to those of Chilean nitrate, and it will be seen what a very large part of the total supply has come from Chile in the past, particularly during the war, and what a considerable part of the supply must come from there or Europe in the future, even with the Government-owned fixed nitrogen plants operating.

SUMMARY.

The preceding consideration of the probable future consumption of inorganic nitrogen for agricultural, industrial, and military purposes and the supply to be expected from the coking of coal and the fixation of nitrogen within this country and the importation of sufficient nitrogen to meet the deficiency in domestic production may be summarized for 1924 and 1930, the two years for which figures have been previously given, as follows:

	Nitrogen.	
	1924	1930
Estimated peace time consumption in—	*Tons.*	*Tons.*
Agriculture	172,000	285,000
Industries	120,000	150,000
Military explosives, assumed	2,500	3,000
Total consumption	294,500	438,000
Estimated domestic supply from—		
Coking of coal	122,500	159,500
Privately owned fixed nitrogen plants	....	25,000
Total domestic supply	122,500	184,500
Deficiency in domestic supply if Government plants do not operate	172,000	353,500
Estimated supply from—		
Government fixed nitrogen plants	45,000	55,000
Deficiency in domestic supply if Government plants operate	127,000	198,500
Estimated imports necessary:		
Canadian cyanamid	15,000	15,000
Chilean or European nitrate, if Government plants not operated	157,000	238,500
Chilean or European nitrate, if Government plants operated	112,000	183,500
Proportion of total consumption furnished by domestic supply:		
If Government plants not operated ... per cent	41.6	42.2
If Government plants operated ... do	56.9	54.7

NOTE.—Nitrogen exported from the United States is not included in the above, as amount of future exports uncertain, and if included only make the deficiency of domestic supply more marked.

In order that the combined effect of the several divisions of consumption and supply may be considered, the next chart (Plate 16) has been prepared. This chart shows two columns for each year, the left-hand one representing the consumption of nitrogen and the right-hand one the supply of nitrogen. The consumption for the different purposes and the supply from the different sources are represented by the different parts of each of the columns, and are the same as given in each of the several component charts previously shown.

A study of this chart will show that the total consumption of nitrogen in this country increased each year from 1900 to 1914 by an average of more than 10 per cent of the consumption during the preceding year. The tremendous demand for nitrogen for military explosives during the World War materially checked this growth in the peace-time uses of nitrogen from 1914 to 1919, but a study will show that the total future consumption of nitrogen has been estimated to continue at practically this same rate of growth, at least for the next 10 years. And this shows that the estimates that have been made of consumption for fertilizer and for industrial uses are conservative for every factor that tended to increase the use of nitrogen in the past will be present to an even greater extent in the future and yet we have assumed a rate of growth in total consumption no greater in the future than in the past.

It will also be noted on this chart how the war requirements, considerably greater than the entire consumption in this country of inorganic nitrogen for all purposes in any year prior to the war, necessitated importing from Chile in 1918 almost three times as much nitrogen as had ever been imported before, and it shows graphically how greatly dependent this country was during the war on this importation.

The chart shows further how the expansion of nitrogen supply from coke ovens and gas works, even though abnormally stimulated by the war demand, will not furnish in the future half of the nitrogen used in this country, and unless this source of supply is supplemented as soon as possible by the operation of the Government fixed-nitrogen plants, and further supplemented by such development of the private fixed-nitrogen industry that there may be, this country will be even more dependent on imported nitrogen 10 years from now than it is at present, and not only will the country be less prepared from a military point of view, but the American consumers which include directly a very large proportion of the farmers of this country as well as many of the most fundamental chemical industries, and indirectly the greater part of the population, will find it harder than ever to get an adequate supply of nitrogen at a cost within reason.

The CHAIRMAN. Have we heard all of your experts, Mr. Secretary?

Secretary BAKER. No, sir; we have a lot more.

Mr. ROBERTS. We are about half through.

The CHAIRMAN. Well, it is getting rather late; we do not want to close the hearings until we have all that you desire to offer, but it will have to be at another time. Whatever papers you have prepared, and have ready to offer, may be printed in the record at this point.

Paper presented by Mr. George J. Roberts:

REASON FOR THE OPERATION OF THE GOVERNMENT-OWNED NITROGEN-FIXATION PLANTS AND WHY THIS SHOULD BE UNDERTAKEN BY THE GOVERNMENT.

I desire to give the reasons for the operation of the Government-owned nitrogen-fixation plants and also the reasons for their operation by a Government-owned corporation.

The Government-owned nitrogen-fixation plants came into being from what might be said to be two different sources of reasoning: No. 1 plant was conceived of as a purely defensive measure; No. 2 plant as a war measure.

Early in this century the attention of the Ordnance Department was called to the operation of certain nitrogen-fixation plants in Sweden, and in 1906 an Army officer was sent to Sweden to look into the operation of these plants. From that time the matter was a live subject in the Ordnance Department. In the report of the Chief of Ordnance to the Secretary of War, dated October 1, 1915, he calls attention to the fact that, in spite of the large natural resources of the United States, there are some articles, essential in time of war, for which it is dependent upon foreign sources of supply—among them nitrates—and he recommends that the Government take steps to have a nitrogen-fixation plant built in the United States. This report brings out the fact that the products of such a plant could be used in peace times for agricultural purposes, it being fully recognized that no art can be kept alive and progress which is brought into useful operation as infrequently as the occurrence of wars.

From this time on the subject was a very live one, and on June 3, 1916, an act "For making further and more effectual provision for the national defense, and for other purposes," was passed. Section 124 of this act, entitled "Nitrate supply," authorizes the President to build a nitrogen-fixation plant, and to operate the same "for the production of nitrates or other products needed for munitions of war and useful in the manufacture of fertilizers and other useful products," and also to build a hydroelectric plant for furnishing the electric current for the operation of such a plant, with the proviso "That the plant or plants provided for under this act shall be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital." This clearly shows that it was the intention of the Government to build a nitrogen-fixation plant for the manufacture of products useful in time of war and other products useful in time of peace, and it is clearly stated that these plants were to be operated and not to be built and allowed to decay.

Under this act, plant No. 1, at Sheffield, was built, and the dam across the Tennessee River, at Muscle Shoals, is now being constructed, which is to furnish the power to operate the nitrogen-fixation plants.

Plant No. 2 came into being on account of the war.

Mr. Baruch, in his testimony before the Graham investigating committee, states:

"Up to about the time that the President appointed the advisory commission that commission was divided into various subdivisions, and I had the honor of being made the chairman of what they called the raw materials division. I immediately undertook a study of those materials which would be necessary in case a war broke out for us to get, how to mobilize them, and how to distribute them. The first thing that I gave my time and thought to were those things that were not within the borders of our country and which we would be stopped from getting in case we were surrounded by an enemy or shut off in any way. The most important item that would strike anybody would be nitrate, not alone because of the great importance of it from a military standpoint, because there can be no explosives and no propellants unless we have nitrates, which is the basis for it, or a substitute thereof; and, furthermore it was of very grave importance to our agricultural interests. Before we entered the war I made a recommendation that the United States Government—and after study it was backed up by the full commission—should have at least a two years' supply, in what we then thought, in our ideas of the war, that we should have a full two years' supply not only for war purposes, but for agricultural purposes."

Mr. Baruch also testifies:

"The matter was finally placed in my hands to handle, with full responsibility; it was put in my hands by the departments and by the President. I looked the situation over and found that we were not producing nitrates, and the major portion that was produced was being taken by speculators. We were constantly being notified by our own fighting forces and the Agricultural Department, and by our Allies, of the necessity for a larger explosive program, and every demand or request or suggestion that came from abroad was increasingly large. * * *"

Mr. Baruch calls attention to the fact that:

"* * * If at this time Germany or the Germans had grasped their opportunity and bought this nitrate through a period of a year or six months, it would be most horrible to contemplate what would have happened, because the whole world was depending on one place to get its nitrates and if the Germans had seized this opportunity and bought this nitrate, or bought the officinas and shut down the production there would not have been sufficient propellants for us to have fought the war with, because there was no other reasonable situation that could have been developed and action taken in time."

He also states:

"At this time we commenced, I think the record will show, that we commenced to feel that we must bolster up this slender and difficult situation with fixed nitrogen processes which the Germans were understood to be adopting. Of course they must have done something of that kind, or else they could not have gone on, we were sure, with their large program."

Mr. Baruch testifies that he became more and more insistent that something be done toward procuring the nitrates by means of nitrogen-fixation plants. He calls attention to the fact that Chile insisted upon being furnished with oil for fuel purposes, if we were to get nitrates. The fact is Chile could have insisted upon almost anything within reason and this Government and its allies would have been compelled to meet these demands or end the war.

Thus we see the reason for plant No. 2.

Mr. A. G. Glasgow, a friend of Mr. E. R. Stettinius and well known in engineering circles in both Europe and America, was asked by Mr. Stettinius to join his staff. When Mr. Stettinius went to France to take charge of purchases for the Government, Mr. Glasgow accompanied him, and while abroad occupied himself with the methods and manufacturing of the explosives and their components. On his return he was invited to look into the subject of nitrogen fixation and to find a solution to the problem of what was to be done with these Government-owned plants. Such a solution was found and is covered in a letter to the Secretary of War under date of October 22, 1919, a copy of which I presume you all have. This letter clearly sets forth the facts. Mr. Glasgow, in his letter of October 22, 1919, to the Secretary of War, says:[1]

"The capture of atmospheric nitrogen in efficiently utilizable form is a new and undeveloped art. Unless the United States nitrate plants, now completing, are brought into continuously developing service, they and their products are likely to be obsolescent and useless in the strenuous competition of future warfare. The only way to secure that these plants shall be always immediately available for most efficient military service and for most efficient and economical extension in case of need, is to operate them continuously, whether in peace or war. Fortunately, from this point of view, nitrogen is as essential in peace as in war. It is as necessary to preserve life as to destroy life; and is the most expensive component of standard fertilizers."

Throughout the entire period of the war the Agricultural Department was voicing the great needs of agriculture for nitrates. The farmer was called upon to produce more and more food, while the Army and the munition factories were taking the men from the farms. The farm not only had to supply its quota of drafted men, but had to fill the ranks in the munition factories depleted by the draft and add materially to them in order that war materials might be produced in sufficient quantities. From this it is clear that more nitrates are needed for the farm during war times than during peace times.

A review of the agricultural needs for nitrates shows that beginning with this century and up to December 31, 1914, the consumption of fertilizers showed a progressive increase of about 7½ per cent per annum. During the war, due to the inability of the farmer to get fertilizers, there was a decrease in the amount of fertilizers used. Since the war, labor troubles and the limited quantity of phosphates and potash available has not permitted the use of fertilizers to increase, as it would have had fertilizer materials been available in sufficient quantity. Sulphate of ammonia, whose prewar price was about $60 a ton, is now $90 a ton for the United States and $140 a ton for export purposes. There is not a sufficient quantity of Chilean nitrate to go around, and the Agriculgural Department is now trying to make arrangements with the Shipping Board to allocate more tonnage for the importation of Chilean nitrates.

It has been estimated by the Department of Agriculture that if nitrate were to be used next year on all of the cultivated land in the United States to the same extent that it is now used in Georgia—a use about the same as England's and less than Germany's—there would be required more than 400,000 tons of nitrogen more than is now used in fertilizers. To furnish this nitrogen would take nearly 2,000,000 tons of sulphate of ammonia, or nearly 2,500,000 tons of Chilean nitrate. If mixed fertilizers were used only to the extent of one-half the amount that is used in the State of Georgia, then the shortage would be at least 150,000 tons of nitrogen, to supply which would take approximately 1,000,000 tons of Chilean nitrate.

Mr. Myers, a representative of the Chilean nitrate interest, stated before the Graham investigating committee that the interest he represented would not be affected by the operation of the Government plants and that in his judgment they should be operated. If the operation of the Government-owned plants would not affect the Chilean nitrate interest, it certainly could not affect any of the domestic sulphate of ammonia producers.

The question naturally arises: "Why does not private industry undertake the operation of these plants?" I shall not attempt to give what is in the minds of those who are most interested in the production of nitrates in this country. All I can state is that months of time was expended attempting to get the fertilizer industry interested in taking over and operating the Government plants. The presidents of all the large fertilizer companies in the United States were seen and the matter fully discussed with them, and they were asked if they would undertake the operation of these plants if they were to pay no rental to the Government until they had received 9 per cent on their working capital and after that the profit should be divided between them and the Government. A part of the agreement was that the United States would complete the plants so as to provide storage and bagging facilities, a sulphate of ammonia plant, and all the work outlined in Mr. Glasgow's letter of October 22. But they could not be brought to the point of making a formal offer. An effort was also made to get certain financiers in New York to undertake to form a company to operate these plants. Scant consideration was given to the scheme and no investigation undertaken. An appeal was likewise made to the coke-oven interest, with the same result. There seems to be a decided antipathy of capital to engage in any partnership arrangement with the Government.

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[1] This letter is printed in full later in the record.

The American Cyanamid Co., relying upon its contract with the Government to receive a considerable compensation in the shape of royalties, without any obligation or responsibility, prefers this means of getting money out of these plants to taking commercial risk in operating them, as evidenced by its president in his testimony before the Graham committee. One of the provisions of the contract between the American Cyanamid Co. and the Government is that after June 1, 1921, the royalty to be paid the American Cyanamid Co. shall be determined by arbitration, and it will be so determined, in strict accordance with the contract. I do not think their payments will be very large; the estimated profit does not show sufficient earnings on investment to warrant the payment of large royalties.

And thus we are left high and dry, and are confronted with the question: "Shall we permit these plants to remain idle and decay, or shall they be operated on a self-sustaining basis by a Government-owned corporation?" I can not recommend that these plants be operated in the same manner and method (yearly appropriations) that the Agricultural Department is operating its kelp undertaking on the Pacific coast. I have no hesitancy in saying that if it is operated under such conditions it will be a certain failure. A business to be run successfully must be able to plan for the future. It must be able to take advantage of markets. It must be free to purchase when in the judgment of its officers raw materials should be purchased, and to sell its product for future delivery without a time limit. And it can not do this if it must wait for the yearly appropriations to be made by Congress. No business can be run unless final authority is vested in some person or group of persons. My experience with governmental undertakings is that there is no final authority and every purchase and every expenditure of money and every sale of property is undertaken in fear and trembling that some statute may exist that prohibits this transaction from being consummated. And this uncertainty can spell but one thing—"inefficiency." Secretary of Interior Lane, in an interview appearing in the Washington Post of March 1, says practically the same.

The corporate plan stands out as the only plan. It asks for the capitalization necessary to carry on the work and then shuts the door and locks it against any future raids upon the United States Treasury. It must present a balance sheet yearly, and it must show to the authorities its stewardship for the previous year, showing whether its officers have operated efficiently or inefficiently. There is no other governmental operation that I know of that has to show such a balance sheet, and this balance sheet is necessary to spur on its officers, since it will pitilessly show whether they are efficient or failures.

In Mr. Glasgow's clear, concise presentation of the operation of the plants and the expected return, it is clearly shown that the margin of profit when operating by steam is so small that it can not be recommended to operate these plants exclusively by steam. They must be operated in conjunction with the cheap water power from the hydroelectric plant now being constructed at Muscle Shoals. One is dependent upon the other.

The Government is building a dam and hydroelectric plant at Muscle Shoals, Ala., under the supervision of the Engineer Corps of the United States Army. This dam will be so built that ultimately there can be installed 200,000 horsepower in water wheels and electric generators. The present undertaking is for the development or installation of only 100,000 horsepower.

All electrical energy is measured in kilowatts, and therefore I shall use kilowatts instead of horsepower, calling attention to the fact that 1 kilowatt is equal to 1⅓ horsepower. Therefore, the present development of 100,000 horsepower is equal to 75,000 kilowatts, the power necessary to operate the nitrate plants, but no surplus.

A study of the flow of the Tennessee River shows that for a number of days, except in exceptional years, it is as low as 75,000 kilowatts, which may last for only a few days. Therefore, any development beyond 100,000 horsepower, or 75,000 kilowatts, must be supplemented by steam. With the facts as set forth above, I shall now go into the problem of what shall be done with this hydroelectric plant. If it is used in conjunction with the nitrogen-fixation plant No. 2, the annual profit to the Government from this combined operation is $2,900,050 and so employed will absorb all the electric power of this first installation.

Mr. Glasgow, in his letter of October 22, 1919, to the Secretary of War shows that the profit from the operation of plant No. 2 with steam power is not great enough to be attractive for either governmental operation or private industry. Therefore, if we are to make use of the dam and the hydroelectric power as a power development only, we can consider the nitrate plants as valueless for the purpose of nitrogen-fixation, and these plants would have to be converted to other purposes, which would mean the scrapping of all the machinery in the present buildings, and we would have only the land and buildings to be salvaged, and the buildings would have to undergo great changes to adapt them to other manufacturing purposes for which they were not designed.

Judging by the bids that have been received for Nitro, W. Va., and nitrate plant No. 3, at Toledo, Ohio, $3,500,000 would be considered a big price for these plants, the Government retaining the steam-power plant as an auxiliary; and if this money were used to retire United States bonds, it would save the Government $148,750 in interest. Subtract this amount from the profit that could be made by operating plant No. 2 with the power generated from this hydroelectric plant, and we have $2,751,300, which would be the amount that the power plant would have to earn in order to equal the profit that could be made from the combined operation of plant No. 2 and the hydroelectric plant.

If this is to be treated strictly as a power proposition, the question arises: "Where will this power be sold?" Sheffield and Florence could use only 2,000 kilowatts. The places that naturally suggest themselves are Memphis, Nashville, Chattanooga, Birmingham, and Atlanta. With the exception of Memphis, all of these cities are already supplied from hydroelectric power-plant development. The greatest amount of revenue that could be obtained from this development would be by the installation of the additional water wheels and electric generators, so as to bring this hydroelectric station up to 200,000 horsepower, or 150,000 kilowatts. The installation of these wheels and generators will cost $2,600.000. The rights of way and transmission lines to these cities will cost from $4,000,000 to $4,500,000. Step-up and step-down transformer stations will cost $1,600,000. This will mean a total of $8,200,000 to bring this electric energy to the distribution systems of one or more of these cities. Memphis would not take more than 25,000 kilowatts capacity; Birmingham proper probably 60,000 kilowatts capacity; the remainder should either go to Atlanta or be divided between Chattanooga and Nashville.

Shall this power be sold to large consumers or sold to the general public, including house lighting? If to large consumers, the distribution system in the cities, presuming the usual amount of underground conduits were installed, would probably cost $50 per kilowatt capacity, or $7,500,000, and if to the general public, $140 per kilowatt capacity, or $21,000,000. Therefore, before we begin the distribution of power we will have expended, if to only large consumers, $15,700,000; if to the general public, $29,200,000; in either case a sum larger than that asked for by the bill which you are now considering.

As I read section 124 of the national defense act, the Government must operate this hydroelectric plant and sell the current to the ultimate consumer. It is prohibited from selling to any of the existing electric-power companies. It is realized that Congress may, by enactment, relieve the situation and permit either the lease of the hydroelectric plant to private interest or the sale of the current wholesale to private interest. If such legislation should be enacted, the additional machinery, transmission lines, step-up and step-down transformer stations, would have to be built either by the Government or by the leasing company, and the lease rental that the Government would be justified in accepting would be the profit that could be made by the operation of the hydroelectric plant in conjunction with the nitrogen-fixation plants, or $2,751,300.

With the working-day becoming shorter and shorter, and the Saturday half holiday becoming more common, due to the demands of labor, and assuming that this power would all be sold to industries which would not be in operation Sundays and holidays, the sales from this plant, supplemented by the steam-power plant, would be 450,000,000 kilowatt hours per annum, and 50,000,000 kilowatt hours of the above would have to be produced by the steam plant. Assuming the cost of operation of the hydroelectric plant at three-fourths of a mill per kilowatt hour, the figure used in our estimates of fertilizer costs, and the cost of current generated by the steam plant at 9 mills per kilowatt hour, due to its intermittent operation and small production, and assuming interest, depreciation, and taxes on the substation and transmission lines at 12 per cent and on the hydroelectric units at 8½ per cent, we find that the total cost of production of current per kilowatt hour is 0.464 of a cent and the rental of $2,751,300 means 0.611 of a cent, or a total cost to the lessor of 1.075 cents per kilowatt hour, while the cost of operating to the power company operating its own plants, including interest, depreciation, and taxes, would not exceed 0.7 of a cent per kilowatt hour. It must not be overlooked that the power companies operating in these communities can build their plants near their distribution centers, and $8,200,000 would go a long way toward their construction, and they would own the plants; whereas if they leased this plant from the Government, they would have to make this $8,200,000 investment, which is useless except in conjunction with the Government plant, and pay a rental of 0.611 of a cent per kilowatt hour. The outstanding feature here is that if current is sold in bulk to an existing power company, the rental of 0.611 of a cent is so large that this power could only be purchased by the power companies as a defensive measure.

If this energy were disposed of to the ultimate consumer, it would displace power stations of the various companies who are now serving their communities and would destroy the value of these companies' power plants, whose replacement cost at present prices would be not less than $100 per kilowatt, or $15,000,000. It would displace $7,500,000 of their distribution system and make it useless. This means that it would make power plants idle whose present reproductive value is $15,000,000 and make distribution systems idle worth $7,500,000 without serving any useful purpose, since these plants are now serving their communities efficiently and cheaply. It would have a very serious effect on the development of utilities throughout the South and would seriously injure the credit of the companies who for the past 25 years have been building up large power companies for the development of manufacturing throughout the South.

If these power plants are not used to manufacture nitrates, they will have to be operated as commercial power plants. Shall we destroy industry, or promote it?

There are five large fertilizer companies and innumerable smaller ones now preparing mixed goods for the market. Some of these own phosphate rock beds and mine and convert phosphate rock into superphosphates by treating the raw rock with sulphuric acid—buying their nitrates and potash. The smaller companies buy the three ingredients that go to make up mixed goods and mix them and sell them to the farmer.

In the 50 years that fertilizer companies have been preparing mixed goods they have spent their energy in educating the consumer to use more and more of their goods and a more intelligent and scientific use of their goods, rather than in investigation of new methods of producing fertilizer compounds and new combinations.

There is need for research work in the production of fertilizers and the means for trying out those discoveries and methods on a scale greater and more comprehensive than can be done in a laboratory. At present there are no such facilities.

To-day is the period of the development of the electric furnace, which really started about 25 years ago, but has only made its great strides within the last 8 or 10 years. No one to-day can foretell to what use these furnaces will be put. They offer a wide field.

There are in Georgia large deposits of potash-bearing shales. There are in the Appalachian Mountains large beds of felspar containing from 9 to 13 per cent potash. The treatment of these by the electric furnace, thereby recovering the potash, if it can be done economically, would be of great benefit to this country, which is so dependent upon foreign sources for its potash. In Tennessee there are large quantities of phosphate rock containing large amounts of iron and aluminum, and these elements add greatly to the cost of converting this rock into superphosphate on account of the excessive amount of sulphuric acid that must be used due to these two deleterious elements.

The reduction of this rock by means of the electric furnace will produce a very high-grade phosphoric acid in liquid form, which can be readily treated with ammonia gas such as will be produced at plant No. 2, forming ammonium phosphate in very concentrated form, which will permit of shipment almost any distance. It is along these lines that our research laboratory has worked, with very good results, suggesting many new methods and some new compounds, an application having been made for a patent for the manufacture of ammonium phosphate.

Muscle Shoals is particularly fortunately located for the carrying on of this electric furnace work. The potash-bearing materials are close at hand, being within from 30 to 125 miles. The phosphate rock mines are also close at hand. The Tennessee River for six months can furnish power for the operation of these furnaces, the only cost being the installation of the water wheels and the electric generators and electric furnaces, and a few men to look after them, no added supervision being necessary. It would seem that the opportunity for accomplishing these results should not be neglected.

To-day it is necessary for the Ordnance Department to keep in stock 300,000 tons of nitrate of soda, most of which is in temporary storage at Rock Island Arsenal, Little Rock, Old Hickory, Savannah, Norfolk, and a great many other places. It is proposed to build a proper storage place for this at Savannah, Ill. The building of such a storage plant would cost from $400,000 to $700,000. If this bill should be passed, the Ordnance Department would feel safe in releasing 150,000 to 175,000 tons of this sodium nitrate for sale to the farmers through the Agricultural Department at cost to the Government. It is estimated that the cost of transporting and providing storage for this 150,000 tons of nitrate of soda will be $1,800,000. If 175,000 tons from these stores could be offered to the farmer at this time, so that it could be used for this year's crop, a price of $70 a ton could be realized, or $12,250,000. Adding the saving in the cost of buildings that would have to be provided for storing this material, plus the freight, plus handling and storing, would total a saving of $14,050,000, which is more than the amount asked for by this bill. Therefore, no new money will have to be raised by taxation if this method of financing is followed.

Can we allow this opportunity to go by to salvage and make useful these plants costing the Government some $85,000,000 not including the dam and the hydroelectric plant, which will become obsolete and decay if not operated, when the operation of the same can be accomplished on a self-sustaining basis, in fact, at a profit to the Government? The farmer needs the nitrates and fertilizer ingredients that can be produced by these plants. Farm labor is scarce. The population in the cities is growing faster than in the country. The farms will show fewer people at this census than 10 years ago, while the cities will show an enormous increase. Therefore, it is essential to produce more food products, and this can only be done by an increase in the yield per acre; and the yield per acre can only be increased by the increased use of fertilizer. All properly balanced fertilizers must contain nitrogen.

In conclusion, I bring to you a business proposition which, if adopted, will salvage what will otherwise be lost—a Government expenditure of some $85,000,000—by turning a now idle plant to useful work, showing an annual profit of about $3,000,000 to the Government, furnish the farmer cheaply with one of the most necessary ingredients in fertilizers, and preserve all of its wartime usefulness, making it possible for the nation to be independent of a single nation (Chile) for that one essential—nitrogen—without which war can not be waged successfully, and by a method of financing that will not add one dollar to the financial burdens of the country.

(Letter from Dr. Milton Whitney, Chief, Bureau of Soils, Department of Agriculture, giving comparative costs of producing phosphoric acid by the sulphuric acid and electric furnace processes, presented by Mr. George J. Roberts:)

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 18, 1920.

MR. GEO. J. ROBERTS,
Special Assistant to Chief of Ordnance, Nitrate Division,
War Department, Washington, D. C.

DEAR MR. ROBERTS: In compliance with your request of March 16, I am appending hereto a sheet of data showing the relative cost of producing phosphoric acid in the electric furnace and by the sulphuric acid method of treatment, assuming electric power at $3 per kilowatt year. With the exception of the power item the other costs are taken from the article by Messrs. Waggaman and Wagner. (Jour. Ind. Eng Chem., vol. 10, No. 5, p. 353, 1918.) It must be understood, however, that the price of sulphuric acid, phosphate rock, and labor have changed materially since these figures were compiled.

Very truly yours,

MILTON WHITNEY, *Chief of Bureau.*

TABLE I.—*Estimated cost*[1] *at the mines of producing available phosphoric acid* (P_2O_5) *by treating high grade phosphate rock with sulphuric acid.*

Items.	Quantity.	Cost of materials per ton.	Total cost of P_2O_5.	
			Per ton.	Per pound.
	Tons.			
Phosphate rock	3.18	$3.50	$11.13	$0.006
Sulphuric acid (50° B.)	3.44	9.90	34.06	.017
Labor and repairs		1.30	8.61	.004
Total			53.80	.027

[1] Exclusive of interest on investment.

TABLE II.—*Estimated cost*[1] *at the mines of producing available phosphoric acid* (P_2O_5) *by treating high grade phosphate rock in an electric furnace.*

Items.	Quantity.	Cost of materials per ton.	Total cost of P_2O_5.	
			Per ton.	Per pound.
	Tons.			
Phosphate rock	3.32	$3.50	$11.62	$0.0058
Sand	1.50	.25	.37	.0002
Coke	.75	8.00	6.00	.003
Operating expenses (electrodes, $2.13; labor, $4.45; power, $5.28)			11.86	.0059
Total			29.85	.0149

[1] Exclusive of interest on investment and assuming power at $3 per horsepower year.

(The recommendations to the Secretary of War, submitted by Mr. Arthur Glasgow, and referred to by Mr. Roberts in his statement, are here printed in full, as follows:)

BRIGHTON HOTEL,
Washington, D. C., October 22, 1919.

To the honorable the SECRETARY OF WAR,
Washington.

DEAR MR. SECRETARY: 1. With the return of our military and agricultural commissions from Europe, our investigations have at last reached conclusions which can now be interpreted into definite recommendations regarding the disposition of

UNITED STATES NITRATE PLANT NO. 2 AT MUSCLE SHOALS.

A convincing feature of these recommendations is that each and every line of investigation, however distinct and whatever the predisposition of investigators, has led invariably to the same conclusions.

2. The war has demonstrated beyond dispute that no nation is safe which is dependent upon a foreign supply of nitrogen. National security demands an adequate domestic supply of high explosives, the consumption of which in modern warfare has been found vastly to surpass all expectations. The cause of the Allies was in constant jeopardy because of the necessity of importing nitrates from Chile; it does not need Lord Fisher's recent articles regarding the future of submarine warfare to demonstrate the uncertainty of importing military supplies; but, while the fundamental requirement of national defense demands self-sufficiency in explosives, this necessity places the United States in a position of some comparative advantages, because only nations able to provide an adequate supply of fixed nitrogen can wage successful war against the United States.

The capture of atmospheric nitrogen in efficiently utilizable form is a new and undeveloped art. Unless the United States nitrate plants now completing are brought into continuously developing service they and their products are likely to be obsolescent and useless in the strenuous competition of future warfare. The only way to secure that these plants shall be always immediately available for most efficient military service and for most efficient and economical extension in case of need is to operate them continuously, whether in peace or war. Fortunately, from this point of view, nitrogen is as essential in peace as in war. It is as necessary to preserve life as to destroy life; and is the most expensive component of standard fertilizers.

3. The following discussion describes how we propose to maintain and continually enhance the military value of United States Nitrate Plant No. 2 at Muscle Shoals, while substituting its peace-time output for imported nitrogen compounds on terms highly beneficial to American agriculture. This will be accomplished not only without additional cost to the United States but while earning interest on about one-half of the total war cost of this plant and accessories!

4. The proper utilization of the smaller United States Nitrate Plant (No. 1) at Sheffield has not yet been determined.

5. The consideration of the Muscle Shoals Plant covers three progressive stages:

Firstly, the period prior to June 1, 1921. During this period we have to pay an operating fee to Air Nitrates Corporation equivalent to $5 per short ton of ammonium nitrate produced (say, $2.48 per ton of dry cyanamid), and, in addition, a royalty of

American Cyanamid Co. and a royalty of 57 cents to Air Reduction Co. per
ry cyanamid produced.
dly, the period from June 1, 1921, until the completion of the hydroelectric
levelopment. During this interim the operating fee is no longer payable, and
alty payable to the American Cyanamid Co. (nominally about $6.33 per ton
yanamid, or 26 per cent more than the combined operating fee and royalty
sly payable) is subject to arbitration. Inasmuch, however, as royalty is
ed by superearning power, it seems certain that little if any royalty would be
d for the use of a process which does not pay Government bond interest upon
roduction value of the essential plant required.
dly, the continuing period of cheap water power subsequent to the completion
hydroelectric development. During this future period we shall have not only
lief from royalty due to arbitration, but the more positive relief due to expiration
ents. It is to be noted that Air Reduction Co.'s royalty of 57 cents per ton of
yanamid is payable until January 13, 1931.
You are so thoroughly acquainted with the problem under discussion that I need
rouble you with the detailed evidence and reasoning upon which we base the
wing statements, leading to our final recommendations:
Inasmuch as there is no considerable present market for the nitrogen products of
Muscle Shoals plant as it now stands, namely, for cyanamid and ammonium
te, it is essential to adapt the plant to the manufacture of a product which is imme-
ely salable in large quantities, in order to carry the burden of slowly building up
mand for these less salable products; otherwise, the operating and overhead ex-
ses of this great plant will swamp the enterprise financially before markets can be
eloped for these products. To this end the manufacture of sulphate of ammonia
he most efficient means; and in the Tennessee Copper & Chemical Corporation we
e a neighbor who is urgently in need of purchasers of large quantities of sulphuric
d, not to speak of sulphuric acid manufacture on our own account. We, therefore,
ommend the installation of neutralizing plant for the manufacture of 110,000 tons
sulphate of ammonia per annum, being one-half of the total capacity of the plant.
gether with coordinate storage and other facilities, at a total structural cost for this
lphate department of about $1,500,000. This is included in paragraph 18, dealing
ith new construction for peace-time operation.

8. It is convenient to reckon the capacity of the Muscle Shoals plant by the number
carbide furnaces in use. There are 12 furnaces altogether, each capable of producing
arbide for 22,225 tons of dry cyanamid per annum. At full capacity of plant, 10 of
hese furnaces are working, two being always in reserve for repairs, etc. The local
team power plant at present capacity will operate eight of these furnaces, and inas-
nuch as power brought from the Government's unit at the Warrior River Station of
he Alabama Power Co. is unduly expensive, it is not intended to operate more than
eight furnaces (or 80 per cent of the total capacity of the plant) until the cheap hydro
electric power is available.

9. Our present expectation is to utilize the capacity of eight carbide furnaces approximately as follows:

Four furnaces (or 40 per cent of plant capacity) for the manufacture of 86,000 tons of ammonium sulphate;

One furnace (or 10 per cent of plant capacity) for the manufacture of 22,225 tons of dry cyanamid—making 24,445 tons of hydrated and oiled cyanamid;

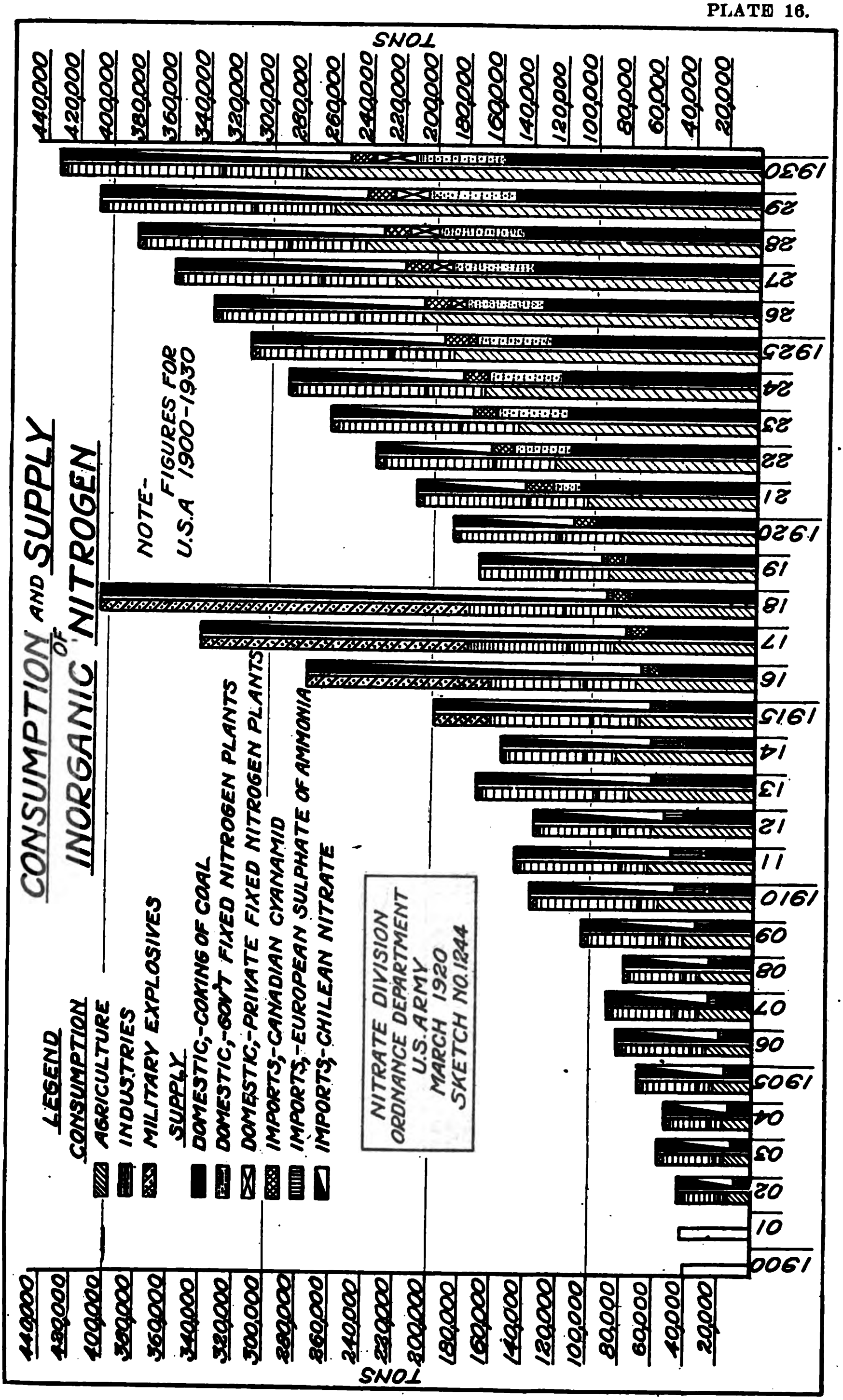
Two furnaces (or 20 per cent of plant capacity) for the manufacture of 22,000 tons of ammonium nitrate;

One furnace (or 10 per cent of plant capacity) for the manufacture of cyanamid, ammonium sulphate, ammonium nitrate, or intermediate product according to demand.

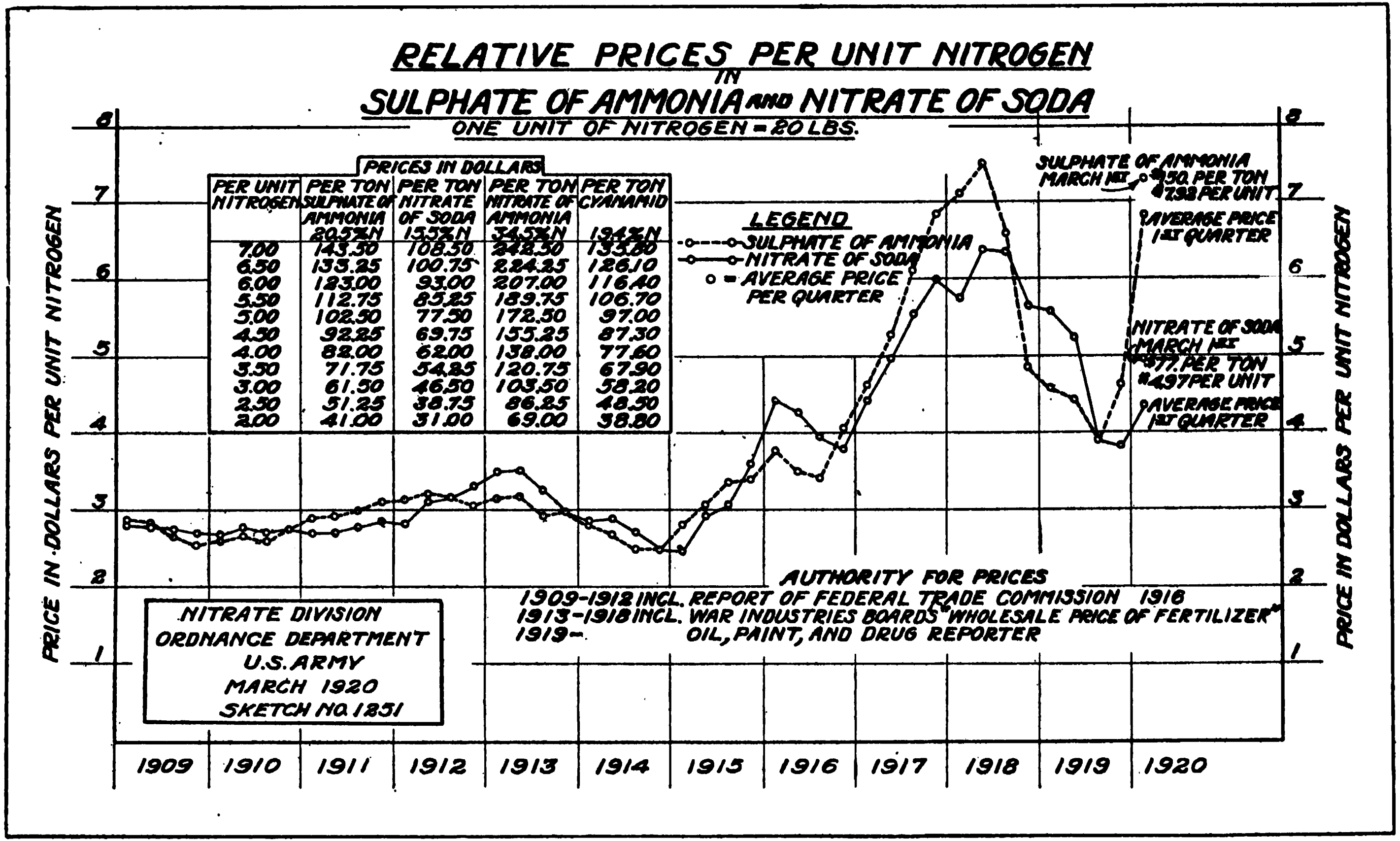
When the hydroelectric power is completed the remaining two furnaces will be applied to the manufacture of the then most advantageous product, possibly ammonium phosphate.

Meanwhile every effort will be made to cultivate the use—firstly of cyanamid, and secondly of ammonium nitrate, in preference to ammonium sulphate; because the cost per unit of nitrogen is much less in those forms than in the form of ammonium sulphate.

10. To ascertain the financial results of the general plan of operation outlined above, we must figure in terms of ammonium sulphate, that being a readily salable commodity of well standardized value. The prewar price of ammonium sulphate was about $60 per ton; it is our best judgment that the postwar prices will average over $70 per ton. (See pl. 17.) Sulphate of ammonia contains about 20.6 per cent and dry cyanamid about 21.1 per cent of nitrogen; whereas ammonium nitrate contains nearly 35 per cent, or more than double the nitrogen content of sodium nitrate from



CONSUMPTION AND SUPPLY OF INORGANIC NITROGEN



RELATIVE PRICES PER UNIT NITROGEN IN SULPHATE OF AMMONIA AND NITRATE OF SODA

ONE UNIT OF NITROGEN = 20 LBS.

PER UNIT NITROGEN	PRICES IN DOLLARS PER TON SULPHATE OF AMMONIA 20.5% N	PER TON NITRATE OF SODA 15.5% N	PER TON NITRATE OF AMMONIA 34.5% N	PER TON CYANAMID 19.4% N
7.00	143.50	108.50	242.50	135.80
6.50	133.25	100.75	224.25	126.10
6.00	123.00	93.00	207.00	116.40
5.50	112.75	85.25	189.75	106.70
5.00	102.50	77.50	172.50	97.00
4.50	92.25	69.75	155.25	87.30
4.00	82.00	62.00	138.00	77.60
3.50	71.75	54.25	120.75	67.90
3.00	61.50	46.50	103.50	58.20
2.50	51.25	38.75	86.25	48.50
2.00	41.00	31.00	69.00	38.80

LEGEND
-o---o- SULPHATE OF AMMONIA
-o—o- NITRATE OF SODA
o = AVERAGE PRICE PER QUARTER
SULPHATE OF AMMONIA MARCH 1ST $150. PER TON $7.32 PER UNIT
AVERAGE PRICE 1ST QUARTER
NITRATE OF SODA MARCH 1ST $77. PER TON $4.97 PER UNIT
AVERAGE PRICE 1ST QUARTER
PRICE IN DOLLARS PER UNIT NITROGEN
8
7
6
5
4
3
2
1
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920

AUTHORITY FOR PRICES
1909-1912 INCL. REPORT OF FEDERAL TRADE COMMISSION 1916
1913-1918 INCL. WAR INDUSTRIES BOARDS "WHOLESALE PRICE OF FERTILIZER"
1919- OIL, PAINT, AND DRUG REPORTER

NITRATE DIVISION
ORDNANCE DEPARTMENT
U.S. ARMY
MARCH 1920
SKETCH NO. 1251

Chile. Moreover, cyanamid contains over 60 per cent of lime, which is a valuable fertilizer in many soils. On the basis of nitrogen content alone, with sulphate of ammonia selling at $70 per ton, hydrated and oiled cyanamid (containing 19.2 per cent of nitrogen) would be worth $65 and ammonium nitrate would be worth $117.50.

11. Unfortunately, the toxic features of cyanamid, combined with its other disabilities and the hygroscopic qualities of ammonium nitrate, interfere with their use for fertilization, as fertilizers as now manufactured and applied. It is, therefore, necessary to give the farmers and fertilizer manufacturers a sufficient reduction in price to induce them to take the trouble to overcome these disabilities. In view of the fact that within three years we expect to have available hydroelectric power for the full capacity of the plant at an operating and maintenance cost (excluding interest on investment) of 0.75 mill, instead of the present steam-power cost of 4 mills per kilowatt hour, we recommend the initial sale of cyanamid at $45 and of ammonium nitrate at $100, compared with sulphate of ammonia at $70 per ton. At this scale of prices a unit of nitrogen in the form of ammonium sulphate would cost 45 per cent more than in the form of cyanamid, or 17½ per cent more than in the form of ammonium nitrate.

12. In other words, we should say to the farmer and to the fertilizer industry:

"We can not sell you ammonium sulphate at less than the market rate, governed by the law of supply and demand; but if you are willing to take the trouble to use your nitrogen fertilizer in the form of cyanamid or ammonium nitrate, we can make you immediately the very great savings described above. We, for our part, undertake to remove the physiological disadvantages of cyanamid by hydrating and oiling, and to relieve the hygroscopicity of ammonium nitrate by coating; and we expect to make further reductions in the prices of cyanamid and nitrate when cheap water power becomes available."

13. Having established the probable selling prices, we must now know the probable costs of the several products in the three periods described in the beginning of this discussion.

Prior to June 1, 1921, if operating continuously, eight of the carbide furnaces (or 80 per cent of the ultimate capacity of the plant), the costs per ton would be as follows:

	Cyanamid (hydrated and oiled).	Nitrate.	Sulphate.
Production costs	$29.02	$80.48	$49.45
Bagging expense	1.75	2.00	.50
Sales expense	1.15	3.08	1.87
Research and Washington office	.95	2.55	1.54
Cost of product	32.87	88.11	53.36

To these must be added royalties and fees to June 1, 1921, as follows:

	Cyanamid (hydrated and oiled).	Nitrate.	Sulphate.
Royalty to Air Reduction Co	$0.52	$1.16	$0.59
Royalty to American Cyanamid Co	2.30	5.11	2.62
Operating fee to Air Nitrates Corporation	2.25	5.00	2.56
Total	5.07	11.27	5.77
Total steam-power costs prior to June 1, 1921	37.94	99.38	59.13

14. For the middle period, from June 1, 1921, until water power is available (say until December, 1922, or 18 months), we may add 10 per cent to "Cost of product" for the first period, in substitution for operating fee, royalties, and contingencies, making:

Total costs from June 1, 1921, until water power is available:

Cyanamid	$36.16
Nitrate	96.90
Sulphate	58.27

15. When water power becomes available at 0.75 mill per kilowatt hour, and with all royalties eliminated, the respective—

Water-power costs will be:

Cyanamid	$24.57
Nitrate	68.50
Sulphate	43.81

The royalty payable to Air Reduction Co. until 1931 is:

Cyanamid	$0.52
Nitrate	1.16
Sulphate	.59

The nominal royalty to American Cyanamid Co., after June 1, 1921, is:

Cyanamid	$5.75
Nitrate	10.40
Sulphate	6.18

But this is subject to arbitration (see par. 5) and to the lapse of patent rights.

It is believed that 10 per cent added to the above "Water-power costs," to cover all the contingencies including royalties, will provide a proper margin of safety. This makes the inclusive water-power costs:

Cyanamid	$27.03
Nitrate	75.35
Sulphate	48.19

16. It must be borne in mind that the estimates of cost for the first two periods, ending when water power becomes available (say, December, 1922), are based upon the continuous operation of eight carbide furnaces, or 80 per cent of the ultimate capacity of the plant. It is obvious that a new industry of these huge dimensions will not thus spring into being; the creation of this unique manufacturing organization and the marketing of this great output must be matters of careful and gradual growth. In fact, this growth will doubtless continue until the water power becomes available, before reaching the full 80 per cent capacity of the present steam-power plant. For this reason, the figures for steam-power costs in the first and second periods are academic rather than practical; they are useful as illustrating the great advantages attaching to cheap water power, rather than as a measure of profit and loss during the initiation of the business. In common with the creation of any new industry, the Muscle Shoals enterprise must sustain initial losses. These are provided for by the "General purposes fund" described in paragraph 20.

17. For any useful conclusion regarding the future financial possibilities of the plant we must look to the permanent water-power costs subsequent to, say, January 1, 1923.

Taking the "inclusive water-power costs," given in paragraph 14 above, and reducing the selling prices of cyanamid, ammonium sulphate, and ammonium nitrate, respectively, to $37.50, $65, and $90 per ton, we have the following balance sheet, with eight furnaces, or 80 per cent of the capacity of the plant, in operation:

	Tons per annum.	Cost.	Per ton sale.	Profit.	Total profit.
Cyanamid	49,000	$27.00	$37.50	$10.50	$514,500.00
Nitrate	22,000	75.35	90.00	14.65	322,300.00
Sulphate	86,000	48.20	65.00	16.80	1,444,800.00
Annual profit for 8 furnaces (80 per cent)					2,281,600.00
Balance sheet when whole plant is in operation:					
Cyanamid	73,500	27.00	37.50	10.50	771,750.00
Nitrate	22,000	75.35	90.00	14.65	322,300.00
Sulphate	107,500	48.20	65.00	16.80	1,806,000.00
Annual profit for 10 furnaces (100 per cent)					2,900,050.00

This $2,900,050 is 5 per cent interest on $58,000,000; while ammonium sulphate at $65 per ton (instead of $70) still costs 61½ per cent more, per unit of nitrogen, than cyanamid at $37.50 per ton, and 21½ per cent more than ammonium nitrate at $90 per ton.

18. To adapt the present plant (which is built exclusively for the production of ammonium nitrate for military explosives) to the manufacture and sale of cyanamid,

ammonium sulphate, ammonium nitrate, and intermediate products, will require the following new construction and equipment—in addition to some $1,000,000 which must yet be expended for military purposes out of present funds:

Oiling and hydrating equipment for 200 tons of cyanamid daily	$150,000
Sulphate of ammonia plant, buildings, and equipment, capacity 300 tons daily	900,000
Storage and bagging for all products, buildings, and equipment	450,000
Acid storage, capacity 20,000 tons	300,000
Tank cars, shipping containers, sidings, and miscellaneous	400,000
Stores (merchandising) for employees	100,000
Office building	100,000
Reserve for extensions and betterments	600,000
Total Fund for New Construction	3,000,000

19. The working capital required for 10 furnaces, or full capacity of plant, will be:

Stocks of raw materials and supplies	$1,600,000
Stocks of manufactured products	2,500,000
Excess of bills receivable over bills payable	2,000,000
Cash	500,000
Total Working Capital	6,600,000

20. A "General Purposes Fund" will be required to provide (*a*) for the payment prior to June 1, 1921, of operating fee and royalty, and (*b*) for the expense of creating the organization and the business starting at nil. Both (*a*) and (*b*) are to be charged to "Good Will," which will be carried as an Asset Account until it is extinguished by profits. The money will thus be restored to "General Purposes Fund," to be used for improvements and betterments and in emergencies, in view of the fact that we shall not have the usual right of corporations to borrow money in case of need.

This general purposes fund should be $2,500,000

21. To summarize, we recommend the promotion of a bill in Congress for—

New construction	$3,000,000
Working capital	6,600,000
General purposes fund	2,500,000
Total Appropriation	12,100,000

This will realize the utmost peace-time advantages of the war investment of $70,000,000 in United States Nitrate Plant No. 2, and of the current investment of $18,000,000 in hydroelectric and navigation development; while, at the same time, it will promote national security by making this plant always the most advanced example of the art—supplying current military requirements, and a model for efficient multiplication in case of need.

22. In addition to granting the necessary funds, namely, $12,100,000, as above, our act of Congress should give us authority to conduct these extraordinary operations so as to utilize the existing plants and this new money with the highest possible efficiency. In other words, we should have authority to establish the administrative organization which will give the best results in such an enterprise. My original memorandum of January 7, 1919, dealing with this subject, expressed the unanimous opinion of all concerned that such an undertaking could not be properly administered by the Army; and my original recommendation was that the fixed-nitrogen administration should be a self-contained bureau of the War Department, under the immediate control of the Secretary of War, but quite independent of the Army. This recommendation was then expanded to include interdepartmental control. But we now revert to my original advice, with the important exception that the Fixed-Nitrogen Administration should be incorporated instead of being a bureau of the War Department.

23. In other words, we recommend that a corporation should be formed to take over all of the fixed-nitrogen assets of the War Department, together with the funds obtained from Congress, and to perform all of the duties of administering these plants and funds in peace time, while continually enhancing their military value. There could be a nominal amount of common stock, of no par value, issued to the United States and held by the Secretary of War, in exchange for the fixed-nitrogen assets of the War Department, and 5 per cent preferred stock could be sold to the United States at par, from time to time as required, to provide the necessary additional funds of $12,100,000 described in paragraph 21 above. The Secretary of War would be chairman of the board. All of the officers and directors would, of course, be appointed and removable by the Secretary of War.

This plan would preserve to the Secretary of War his complete control of the undertaking, while giving the responsible officials of this independent agency full executive and administrative freedom in the pursuit of efficiency.

24. I have sought advice in numerous quarters, and all of it strongly supports this conclusion in favor of incorporation. To check this conclusion, I have endeavored to sketch a supposititious order by the Secretary of War establishing the fixed-nitrogen administration as a departmental bureau to give effect to the anticipated congressional appropriations. I attach this draft marked "Exhibit A;" but I find myself quite incapable of producing any instrument which is a fit substitute for the accumulated experience of all past corporation management, as now reflected in corporation procedure. Briefly, it seems to me there is nothing to lose and everything to gain by the process of incorporation.

25. I have, therefore, retained Milton Elliott, counsel for the Federal Reserve Board since its inception until last spring, to draft the proposed bill which is presented herewith to your consideration; and I venture to ask you to make time for an immediate discussion of the points involved. I have to be urgent, because I am sailing for London November 1.

With high respect,
Yours, most sincerely,
Arthur Glasgow.

Estimate of Costs of Manufacturing Products, United States Nitrate Plant No. 2, Muscle Shoals, Ala.

Presented by Mr. George J. Roberts.

1. It is the purpose of these estimates to show the cost of commercial cyanamid sulphate of ammonia, and nitrate of ammonia manufactured under the proposed plan of operation at United States Nitrate Plant No. 2. These estimates apply to the operation of 8 of the 10 regularly operating carbide furnaces and corresponding equipment for the production of lime nitrogen or crude cyanamid. One-quarter of the lime nitrogen produced will be oiled and hydrated to produce 49,000 tons of commercial cyanamid per year, one-quarter will be used to make 22,000 tons of nitrate of ammonia per year, and one-half to make 86,000 tons of sulphate of ammonia per year. Operation of the plant at full capacity would undoubtedly result in some saving over the costs shown here.

2. Five main items, "Production cost," "Bagging," "Sales," "Research and Washington office," and "Royalties and fees," enter into the final cost of these products f. o. b. cars Muscle Shoals, Ala.

3. In the production cost estimates the quantity of raw materials and power used in the manufacture of the several products are based on the actual results of the two weeks' operating test of the plant at one-fifth capacity in January, 1919. The quantity of materials used in the several manufacturing processes were carefully measured and weighed daily and the consumption for the entire period of the test thus determined and the products manufactured carefully determined.

4. The unit prices of materials are those which existed at the time the estimate was made, in the summer of 1919, and it is believed will prevail as conditions become more stabilized.

5. The items for repairs and maintenance have been estimated on the basis of total yearly expense, and this amount, $488,134 labor and $259,527 material, $747,661 total, has been prorated over the several products. This allowance is based upon experience and is liberal.

6. A detailed labor organization sheet has been prepared, giving the number of men necessary, together with their rates of pay, for the operation, maintenance, and supervision of every part of the plant, and is submitted herewith. To this there is added 10 per cent for contingencies.

7. In estimating bagging expense it has been assumed that all the commercial cyanamid and all the nitrate of ammonia must be bagged, but that two-thirds of the sulphate of ammonia will be shipped in bulk.

8. Sales expense has been estimated at 3½ per cent of the cost f. o. b. Muscle Shoals. That this is a liberal allowance is shown by the fact that a large sales company in the last month has offered to undertake these sales for 2 per cent.

9. Research and Washington office expense has been estimated at $235,000 per year and prorated according to cost of products.

10. Expense for royalties and fees has been figured in accordance with the provisions of the present contracts with the American Cyanamid Co. and its subsidiary, the Air Nitrates Corporation, and with the Air Reduction Co., due consideration being given to arbitration clauses in estimates of cost after June 1, 1921.

11. These estimates do not include any allowance for interest on capital cost, depreciation and obsolescence, or taxes and insurance. These estimates are also based upon the assumption that all community arrangements will be self-supporting in so far as current operating expenses are concerned.

Estimated cost of final products.

	Commercial cyanamid.	Nitrate of ammonia.	Sulphate of ammonia.
Steam-power costs:			
Production cost, using steam power	$29.02	$80.48	$49.45
Bagging and loading	1.75	2.00	[1] .50
Sales	1.15	3.08	1.87
Research and Washington office	.95	2.55	1.54
Before June 1, 1921—			
Cost without royalties, using steam power	32.87	88.11	53.36
Royalties and fees to June 1, 1921	5.07	11.27	5.77
Cost f. o. b. cars Muscle Shoals before June 1, 1921, using steam power.	37.94	99.38	59.13
After June 1, 1921—			
Allowance for royalties after June 1, 1921, assuming reduction by arbitration	3.29	8.81	5.34
Cost f. o. b. cars Muscle Shoals after June 1, 1921, using steam power..	36.16	96.92	58.70
Water-power costs:			
After Dec. 1, 1922—			
Production cost, using water power	29.72	60.87	39.90
Bagging	1.75	2.00	.50
Sales	1.15	3.08	1.87
Research and Washington office	.95	2.55	1.54
Cost without royalties, using water power	24.57	68.50	43.81
Allowance for royalties after June 1, 1921, assuming reduction by arbitration	2.46	6.85	4.38
Cost f. o. b. cars Muscle Shoals after June 1, 1921, using water power..	27.03	75.35	48.19

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[1] Average for entire output; estimated less than 35 per cent of product will be bagged.

DETAILED ESTIMATES OF PRODUCTION COSTS.

Estimated production cost of lime nitrogen.

Item.	Quantity per ton of lime nitrogen.	Unit cost.	Cost per ton of lime nitrogen.	
			Using steam power.	Using water power.
Limestone	1.75 tons	$1.25	$2.19	$2.19
Coke	0.54 tons	6.00	3.24	3.24
Coal	0.21 tons	4.00	.84	.84
Electrodes	37.8 pounds	.05	1.89	1.89
Steam power	2,808 kilowatt-hours	.004	11.23	
Water power	do.	.00075		2.10
Charcoal and diluent			.59	.59
Caustic soda			.13	.13
Miscellaneous materials			.86	.86
Repair parts			1.08	1.08
Labor (operation)			5.09	5.09
Labor (maintenance)			2.11	2.11
Superintendence			1.58	1.58
Fire department			.27	.27
Total			31.10	21.97

Estimated production cost of commercial cyanamid.

One ton of lime nitrogen, when oiled and hydrated, produces approximately 1.10 tons commercial cyanamid, at an estimated cost of $0.75 per ton for oil and oiling.

$31.10÷1.10	$28.27
Oil and oiling	.75
Production cost of commercial cyanamid using steam power	29.02
$21.97÷1.10	19.97
Oil and oiling	.75
Production cost of commercial cyanamid using water power	20.72

Estimated production cost of ammonia gas.

Item.	Quantity per ton of ammonia gas.	Unit cost.	Cost per ton ammonia gas.	
			Using steam power.	Using water power.
Lime nitrogen	4.025 tons	$31.10	$125.18	
Do	do	21.97		$88.43
Steam power	130 kilowatt-hours	.004	.52	
Water power	do	.00075		.10
Soda ash	0.134 tons	25.00	3.35	3.35
Steam	8 M pounds	.285	2.28	2.28
Compressed air	2.7 M cubic feet	.013	.04	.04
Miscellaneous supplies and repair parts			.75	.75
Labor (operation)			4.06	4.06
Labor (maintenance)			.70	.70
Additional superintendence			.42	.42
Total			137.30	100.13

NOTE.—Lime nitrogen when produced by steam power costs $31.10 per ton, by water power $21.97.

Estimated production cost of sulphate of ammonia.

Item.	Quantity per ton of sulphate.	Unit cost.	Cost per ton sulphate.	
			Using steam power.	Using water power.
Ammonia gas	0.257 tons	$137.30	$35.28	
Do	do	100.13		$25.84
Steam power	35 kilowatt-hours	.004	.14	
Water power	do	.00075		.03
Sulphuric acid, 60°	0.96 ton	10.00	9.60	9.60
Coal, steam, air			.11	.11
Miscellaneous supplies and repair parts			.70	.70
Labor (operation)			2.77	2.77
Labor (maintenance)			.57	.57
Additional superintendence			.28	.28
Total			49.45	39.90

NOTE.—Ammonia gas produced by steam power costs $137.30 per ton; by water power, $100.13.

Estimated production cost of nitric acid (computed on basis of 100 per cent acid).

Item.	Quantity per ton of nitric acid.	Unit cost.	Cost per ton nitric acid.	
			Using steam power.	Using water power.
Ammonia gas	0.317 tons	$137.30	$43.52	
Do	do	100.13		$31.74
Steam power	344 kilowatt-hours	.004	1.37	
Water power	do	.00075		.25
Compressed air	42.37 M cubic feet	.013	.55	.55
Miscellaneous supplies and repair parts			1.95	1.92
Labor (operation)			2.02	2.05
Labor (maintenance)			1.23	1.23
Additional superintendence			.24	.24
Total			50.88	37.98

NOTE.—Ammonia gas produced by steam power costs $137.30 per ton; by water power $100.13.

Estimated production cost of nitrate of ammonia.

Item.	Quantity per ton of nitrate.	Unit cost.	Cost per ton nitrate.	
			Using steam power.	Using water power.
Nitric acid	0.858 ton	$50.88	$43.66	
Do	do	37.98		$32.68
Ammonia gas	0.230 ton	137.30	31.58	
Do	do	100.13		23.03
Steam power	25 kilowatt-hours	.004	.10	
Water power	do	.00075		.02
Compressed air	14.33 M cubic feet	.013	.19	.19
Steam	1.86 M pounds	.285	.53	.53
Miscellaneous supplies and repair parts			.60	.60
Labor (operation)			2.61	2.61
Labor (maintenance)			.80	.80
Additional superintendence			.41	.41
Total			80.48	60.87

NOTE.—Nitric acid when made from ammonia produced by steam power cost $50.88 per ton; by water power, $37.98. Ammonia gas produced by steam power cost $137.30; by water power, $100.13.

ROYALTIES AND FEES.

	Royalty to—		Operating fee to Air Nitrates Corporation.	Total per ton.
	Air Reduction Co.	American Cyanamid Co.		
Before June 1, 1921:				
Commercial cyanamid	[1] $0.522	[2] $2.301	[3] $2.25	$5.073
Nitrate of ammonia	[1] 1.16	[2] 5.114	[3] 5.00	11.274
Sulphate of ammonia	[1] .594	[2] 2.618	[3] 2.558	5.770
After June 1, 1921:				
Commercial cyanamid	[1] .522	[2] 5.753		6.275
Nitrate of ammonia	[1] 1.16	[2] 10.395		11.555
Sulphate of ammonia	[1] .594	[2] 6.176		6.770

[1] Royalty to Air Reduction Co. until January, 1931, is $2.72 per ton of nitrogen fixed as lime nitrogen; after that date there will be no royalty charge.

[2] Royalty to American Cyanamid Co. until June 1, 1921, is $12 per ton of nitrogen fixed as lime nitrogen. After that date it is $30 per ton of nitrogen content in any and all products manufactured, the figure $30, however, being subject to arbitration.

[3] Operating fee to the Air Nitrates Corporation, payable only until June 1, 1921, is $5 per ton of nitrate o ammonia, or equivalent amount on other products manufactured.

DETAILS OF LABOR.

Summary of pay roll.

	Number of men.	Yearly pay roll.
Operating force	840	$1,249,103
Maintenance force	244	438,070
Superintendence	184	282,700
Total	1,268	1,969,873
10 per cent added for contingencies	127	196,987
Grand total	1,395	2,166,860

NOTE.—In addition to the force shown above, 141 men will be employed in general utilities—steam electric power, process steam and compressed air. The pay roll for these men amounts to $228,267 per year, and this appears in the detailed estimates of production costs as a part of the cost of steam power, process steam, and compressed air. This brings the force up to 1,536. This total does not include men engaged in bagging and loading, or those engaged in self-supporting community activities.

OPERATING FORCE.

Summary of pay rolls by departments.

	Number of men.	Daily pay roll.
Lime nitrogen:		
Coke mill	10⅔	$46.43
Coal mill	10⅔	59.43
Limekiln	23⅔	101.63
Raw materials and yard	39	156.10
Raw materials building	6	16.80
Carbide furnace	233	911.60
Electrode shop	19	85.47
Carbide mill	46	176.49
Liquid air	62	283.47
Lime-nitrogen oven room	64	250.00
Lime-nitrogen mill and cooling shed	43	168.10
Total	560	[1] 2,255.52
Ammonia gas:		
Hydrating building	6.8	30.72
Autoclaves	64.2	247.65
Filter building	15	56.40
Total	86	[1] 334.77
Sulphate of ammonia:		
Total force	140	[1] 593.17
Nitric acid:		
Total force	20	[1] 95.68
Nitrate of ammonia:		
Neutralizer section	12½	54.74
Nitrate section	21½	88.34
Total	34	[1] 143.08
Grand total	840	3,422.22

[1] In carrying this amount forward to detailed estimates of production cost, 10 per cent has been added to cover contingencies, etc.

Detailed pay roll.

LIME NITROGEN.

Rating.	No.	Daily pay roll.
Coke mill:		
Superintendent, $300 per month	⅓	$3.33
Clerk, $135 per month	⅓	1.50
Shift foreman, $180 per month	1	6 00
Dryer operators, $0.55 per hour	3	13 20
Crusher operators, $0.525 per hour	2	8.40
Conveyor operators, $0.525 per hour	2	8.40
Laborers, $0.35 per hour	2	5.60
Total	10⅔	46.43
Coal mill:		
Superintendent, $300 per month	⅓	3.33
Clerk, $135 per month	⅓	1.50
Shift foreman, $180 per month	1	6.00
Dryer operators, $0.55 per hour	3	13.20
Pulverizer operators, $0.60 per hour	3	14.40
Conveyor operators, $0.525 per hour	3	12.60
Laborers, $0.35 per hour	3	8.40
Total	13⅔	59.43
Lime kiln:		
Superintendent, $300 per month	⅓	3.33
Clerk, $135 per month	⅓	1.50
Shift foreman, $180 per month	1	6.00
Kiln operators, $0.65 per hour	9	46.00
Conveyor operators, $0.525 per hour	6	25.20
Laborers, $0.35 per hour	7	19.60
Total	25⅔	101.65
Raw materials and yard:		
Yard foreman, $195 per month	1	6.50
Locomotive engineers, $6 per day	2	12.00
Locomotive firemen, $4.40 per day	2	8.80
Brakemen, $4.40 per day	2	8.80
Conductors, $6 per day	2	12.00
Crane engineers, $6 per day	5	30.00
Crane firemen, $4.40 per day	5	22.00
Laborers, $0.35 per hour	20	56.00
Total	39	156.10
Raw-material building:		
Laborers, $0.35 per hour	6	16.80
Total	6	16.80
Carbide furnace room:		
Superintendent, $300 per month	1	10.00
Shift foremen, $200 per month	3	20.00
Clerk, $150 per month	1	5.00
Furnace men (first class), $0.625 per hour	9	45.00
Furnace men (second class), $0.45 per hour	120	432.00
Tappers (first class), $0.625 per hour	24	120.00
Tappers (second class), $0.45 per hour	24	86.40
Locomotive drivers, $0.525 per hour	9	37.80
Locomotive helpers, $0.525 per hour	6	25.20
Cranemen, $0.525 per hour	3	12.60
Belt men, $0.55 per hour	3	13.20
Belt-men helpers, $0.45 per hour	6	21.60
Weighers, $0.525 per hour	6	25.20
Weighers' helpers, $0.45 per hour	9	32.40
Laborers, $0.35 per hour	9	25.20
Total	233	911.60
Electrode shop:		
Foreman, $200 per month	1	6.67
Drillers, $0.55 per hour	2	8.80
Planers, $0.55 per hour	2	8.80
Pipe fitters, $0.875 per hour	3	21.00
Assemblers, $0.55 per hour	3	13.20
Assembler helpers, $0.45 per hour	4	14.40
Cranemen, $0.525 per hour	1	4.20
Laborers, $0.35 per hour	3	8.40
Total	19	85.47

Detailed pay roll—Continued.

LIME NITROGEN—Continued.

Rating.	No.	Daily pay roll.
Carbide mill:		
Superintendent, $300 per month	½	$5.00
Shift foremen, $190 per month	3	18.99
Clerks, $150 per month	½	2.50
Crusher operator, $0.525 per hour	3	12.60
Hardinge mill operators, $0.525 per hour	3	12.60
Smidth mill operators, $0.525 per hour	3	12.60
Smidth mill helpers, $0.425 per hour	3	10.20
Conveyor operators, $0.525 per hour	3	12 60
Locomotive drivers, $0.40 per hour	3	9.60
Crane operators, $0.525 per hour	3	12.60
Chill car operators, $0.40 per hour	6	19.20
Laborers, $0.40 per hour	15	48.00
Total	46	176.49
Liquid air:		
Superintendent, $350 per month	1	11.67
Clerk, $135 per month	1	4.50
Shift foremen, $7.50 per day	3	22.50
Column operators, $0.55 per hour	36	158.40
Compressor operators, $0.55 per hour	9	39.60
Soda tower operators, $0.525 per hour	6	25.20
Switchboard operators, $0.55 per hour	3	13.20
Laborers, $0.35 per hour	3	8.40
Total	62	283.47
Lime nitrogen oven room:		
Superintendent, $300 per month	1	10.00
Shift foremen, $200 per month	3	20.00
Clerk, $150 per month	1	5.00
Head paper man, $0.45 per hour	1	3.60
Paper men, $0.35 per hour	4	11.60
Chargers, $0.625 per hour	6	30.00
Dischargers, $0.55 per hour	3	13.20
Crane men, $0.525 per hour	9	37.80
Conveyor men, $0.45 per hour	3	10.80
Oven attendents, $0.40 per hour	21	67.20
Pencil men, $0.50 per hour	6	24.00
Laborers, $0.35 per hour	6	16.80
Total	64	250.00
Lime nitrogen mill and cooling shed:		
Superintendent, $300 per month	½	5.00
Shift foreman, $190 per month	3	19.00
Clerk, $150 per month	½	2.50
Crane men, $0.525 per hour	6	25.20
Crane men helpers, $0.40 per hour	6	19.20
Crusher operators, $0.525 per hour	3	12.60
Hardinge mill operators, $0.525 per hour	3	12.60
Smidth mill operators, $0.525 per hour	3	12.60
Conveyor men, $0.525 per hour	3	12.60
Crane men, $0.45 per hour	6	21.60
Laborers, $0.35 per hour	9	25.20
Total	43	168.10
Grand total	560	2,255.52

NOTE.—The above totals are carried over to summary without adding 10 per cent for contingencies, etc.

AMMONIA GAS

Hydrating building:		
Superintendent, $300 per month	0.1	$1.00
Shift foreman, $200 per month	.3	2.00
Clerk, $125 per month	.1	.42
Chief operators, $0.625 per hour	.3	1.50
Operators, $0.55 per hour	3.0	13.20
Conveyor man, $0.525 per hour	3.0	12.60
Total	6.8	30.72

Detailed pay roll—Continued.

AMMONIA GAS—Continued.

Rating.	No.	Daily pay roll.
Autoclaves:		
Superintendent, $300 per month	0.9	$9.00
Shift foremen, $200 per month	2.7	18.00
Clerk, $125 per month	.9	3.75
Chief operators, $0.625 per hour	2.7	13.50
Top operators, $0.55 per hour	12	52.80
Top operator helpers, $0.50 per hour	12	48.00
Bottom operator, $0.45 per hour	6	21.60
Bottom operator helpers, $0.40 per hour	6	19.20
Weigher, $0.45 per hour	12	32.40
Conveyor men, $0.525 per hour	3	12.60
Laborers, $0.35 per hour	6	16.80
Total	64.2	247.65
Filter building:		
Operators, $0.55 per hour	3	13.20
Operatorshelpers, $0.45 per hour	6	21.60
Pump men $0.55 per hour	3	13.20
Laborers, $0.35 per hour	3	8.40
Total	15	56.40
Grand total	86	334.77

NOTE.—The above totals are carried over to summary without adding 10 per cent for contingencies, etc.

SULPHATE OF AMMONIA.

Superintendent, $300 per month	1	$10.00
Foremen, $180 per month	3	18.00
Clerk, $125 per month	1	4.17
Centrifugal men, $0.5625 per hour	42	189.00
Centrifugal helpers, $0.50 per hour	42	168.00
Absorber men, $0.625 per hour	12	60.00
Absorber helpers, $0.50 per hour	12	48.00
Drier men, $0.5625 per hour	12	54.00
Laborers, $0.35 per hour	15	42.00
Total	140	593.17

NOTE.—The above totals are carried over to summary without adding 10 per cent for contingencies, etc.

NITRIC ACID.

Superintendent, $300 per month	½	$5.00
Foreman, $200 per month	3	20.00
Clerk, $125 per month	½	2.08
Platinum repair man, $150 per month	1	5.00
Chief operator, $150 per month	3	15.00
Tower men, $150 per month	3	15.00
Operators, $0.50 per hour	3	12.00
Tower men helpers, $0.45 per hour	6	21.60
Total	20	95.68

NOTE.—The above totals are carried over to summary without adding 10 per cent for contingencies, etc.

NITRATE OF AMMONIA.

Neutralizer section:		
Superintendent, $300 per month	¼	$2.50
Clerk, $125 per month	¼	1.04
Shift foremen, $200 per month	3	20.00
Operators, $0.50 per hour	3	12.00
Operator helpers, $0.45 per hour	3	10.80
Laborers, $0.35 per hour	3	8.40
Total	12½	54.74

Detailed pay roll—Continued.

NITRATE OF AMMONIA—Continued.

Rating.	No.	Daily pay roll.
Nitrate section:		
Superintendent, $300 per month	¼	$2.50
Clerk, $125 per month	¼	1.04
Shift foremen, $200 per month	3	20.00
Evaporator operators, $0.55 per hour	3	13.20
Grainer operators, $0.55 per hour	3	13.20
Operator helpers, $0.45 per hour	6	21.60
Laborers, $0.35 per hour	6	16.80
Total	21½	88.34
Grand total	34	143.08

NOTE.—The above totals are carried over to summary without adding 10 per cent for contingencies etc.

Maintenance force.

Rating.	Rate of pay.	No.	Daily pay roll.	Charged to— Lime nitrogen. No.	Lime nitrogen. Daily pay roll.	Ammonia gas. No.	Ammonia gas. Daily pay roll.	Sulphate of ammonia. No.	Sulphate of ammonia. Daily pay roll.	Nitric acid. No.	Nitric acid. Daily pay roll.	Nitrate of ammonia. No.	Nitrate of ammonia. Daily pay roll.
Mechanical superintendent	$5,000.00	1	$13.70	1	$13.70	....	....	....	....	....	....	....	....
Master mechanic	3,600.00	1	9.90	1	9.90	....	....	....	....	....	....	....	....
Chief electrician	3,600.00	1	9.90	1	9.90	....	....	....	....	....	....	....	....
Draftsmen	1,500.00	5	20.63	5	20.63	....	....	....	....	....	....	....	....
Clerks	1,500.00	4	16.42	4	16.42	....	....	....	....	....	....	....	....
Stenographers	1,200.00	2	6.67	2	6.67	....	....	....	....	....	....	....	....
Foreman, machinist	2,000.00	1	5.50	1	5.50	....	....	....	....	....	....	....	....
Foreman, pipefitter	2,000.00	1	6.50	1	5 50	....	....	....	....	....	....	....	....
Foreman, carpenter	2,000.00	1	5.50	1	5.50	....	....	....	....	....	....	....	....
Foremen, electrician	2,000.00	2	11 00	2	11.00	....	....	....	....	....	....	....	....
Foreman, labor	2,000 00	1	5 50	1	5 50	....	....	....	....	....	....	....	....
Machinists	p.d. 6 00	13	78.00	12	72.00	....	....	1	$6.00	....	....	....	....
Pipefitters	p.d 7.00	10	70 00	9	63.00	....	....	1	7.00	....	....	....	....
Steamfitters	p.d 7.00	6	42.00	....	....	2	$14.00	....	....	2	$14 00	2	$14.00
Steamfitter's helpers	p.d 3 60	6	21.60	....	....	2	7.20	....	....	2	7.20	2	7.20
Plumbers	p.d. 7.00	2	14.00	2	14.00	....	....	....	....	....	....	....	....
Carpenters	p.d. 5.00	15	75.00	11	55.00	....	....	4	20.00	....	....	....	....
Blacksmiths	p.d. 5.60	2	11.20	2	11.20	....	....	....	....	....	....	....	....
Blacksmiths helpers	p.d. 3.60	4	14.40	4	14.40	....	....	....	....	....	....	....	....
Tinsmiths	p.d. 7.00	4	28.00	4	28.00	....	....	....	....	....	....	....	....
Painters	p.d. 6.00	5	30.00	4	24.00	....	....	1	6.00	....	....	....	....
Masons	p.d. 7.00	9	63.00	7	49.00	....	....	1	7.00	1	7.00	....	....
Masons helpers	p.d. 3.60	1	3.60	....	....	....	....	....	....	1	3.60	....	....
Electricians	p.d. 6.00	30	180.00	24	144.00	1	6.00	1	6.00	3	18.00	1	6.00
Millwrights	p.d. 4.80	33	158.40	24	115.20	3	14.40	4	19.20	....	....	2	9.60
Millwright helpers	p.d. 3.60	33	118.80	24	86.40	3	10.80	4	14.40	....	....	2	7.20
Welders	p.d. 7.00	3	21.00	3	21.00	....	....	....	....	....	....	....	....
Riggers	p.d. 7.00	3	21.00	3	21.00	....	....	....	....	....	....	....	....
Lead burners	p.d. 8.00	2	16.00	....	....	....	....	2	16.00	....	....	....	....
Lead burners' helpers	p.d. 3.60	2	7.20	....	....	....	....	2	7.20	....	....	....	....
Filter recoverer	p.d. 4.80	1	4.80	....	....	1	4.80	....	....	....	....	....	....
Laborers	p.d. 2.80	40	112.00	32	89.60	....	....	5	14.00	3	8.40	....	....
Total	....	244	1,209.22	185	918.02	12	57.20	26	122.80	12	58.20	9	44.00

The above does not include the 10 per cent allowance for contingencies, etc., which is added to all labor items which appear in the detailed estimates of production cost.

Superintendence.

Rating.	Salary per year.	No.	Yearly pay roll.	Charged to—									
				Lime nitrogen.		Ammonia gas.		Sulphate of ammonia.		Nitric acid.		Nitrate of ammonia.	
				No.	Yearly pay roll.	No.	Yearly pay roll.	No.	Yearly pay roll.	No.	Yearly pay roll.	No.	Yearly pay roll.
General office and supervisory force:													
Works manager	$7,500	1	$7,500	1	$7,500								
Assistant to works manager	2,400	3	7,200	2	4,800			1	$2,400				
Paymaster	2,400	1	2,400	1	2,400								
Purchasing agent	3,600	1	3,600	1	3,600								
Assistant purchasing agent	2,700	1	2,700	1	2,700								
Accountants	2,000	4	8,000	3	6,000			1	2,000				
General superintendent	5,000	1	5,000	1	5,000								
Assistant general superintendent	3,000	1	3,000	1	3,000								
Technical assistant	2,500	1	2,500	1	2,500								
Do	1,800	2	3,600	2	3,600								
Draftsmen	1,800	2	3,600	2	3,600								
Clerks, special	1,800	8	14,400	8	14,400								
Clerks	1,500	19	28,500	16	24,000	2	$3,000	1	1,500				
Do	1,400	14	19,600	9	12,600	2	2,800	1	1,400	1	$1,400	1	$1,400
Do	1,200	8	9,600	7	8,400			1	1,200				
Stenographers	1,400	12	16,800	9	12,600	1	1,400	1	1,400			1	1,400
Typists	1,200	10	12,000	7	8,400	1	1,200	1	1,200			1	1,200
Telephone operators	900	4	3,600	4	3,600								
Timekeepers	1,200	18	21,600	13	15,600	1	1,200	2	2,400	1	1,200	1	1,200
Janitors	800	3	2,400	3	2,400								
Messengers and office boys	400	6	2,400	6	2,400								
Total		120	180,000	98	149,100	7	9,600	9	13,500	2	2,600	4	5,200
Chemical laboratory force:													
Chief chemist	4,000	1	4,000	1	4,000								
Chemists	2,400	7	16,800	6	14,400			1	2,400				
Analysts	1,500	34	51,000	25	37,500	2	3,000	4	6,000	1	1,500	2	3,000
Typists	1,200	2	2,400	2	2,400								
Clerk	1,500	1	1,500	1	1,500								
Total		45	75,700	35	59,800	2	3,000	5	8,400	1	1,500	2	3,000
First aid:													
Doctor	2,800	1	2,800	1	2,800								
Nurses	1,400	3	4,200	3	4,200								
Total		4	7,000	4	7,000								
Transportation force:													
Transportation foreman	2,200	1	2,200	1	2,200								
Motor mechanics	1,800	1	1,800	1	1,800								
Chauffeurs	1,000	6	6,000	6	6,000								
Total		8	10,000	8	10,000								
Water and sewage force:													
Foreman	2,800	1	2,800	1	2,800								
Operators	1,200	6	7,200	6	7,200								
Total		7	10,000	7	10,000								
Total		184	282,700	152	235,900	9	12,600	14	21,900	3	4,100	6	8,200
Total, plus 10 per cent for contingencies, etc		...	310,970	....	259,490	....	13,860	....	24,090	....	4,510	....	9,020

Superintendence—Continued.

Rating.	Salary per year.	No.	Yearly pay roll.	Charged to— Lime nitrogen. No.	Lime nitrogen. Yearly pay roll.	Ammonia gas. No.	Ammonia gas. Yearly pay roll.	Sulphate of ammonia. No.	Sulphate of ammonia. Yearly pay roll.	Nitric acid. No.	Nitric acid. Yearly pay roll.	Nitrate of ammonia. No.	Nitrate of ammonia. Yearly pay roll.
Supplies:													
Office	....	....	$9,000	....	$9,000	....	....	....	....	....	....	....	....
Laboratory	....	....	7,500	....	7,500	....	....	....	....	....	....	....	....
First-aid	....	....	1,000	....	1,000	....	....	....	....	....	....	....	....
Transportation	....	....	2,000	....	2,000	....	....	....	....	....	....	....	....
Water and sewage	....	....	2,000	....	2,000	....	....	....	....	....	....	....	....
Total	....	....	21,500	....	21,500	....	....	....	....	....	....	....	....
Grand total	....	....	332,470	....	280,990	....	$13,860	....	$24,090	....	$4,510	....	$9,020

NOTE.—In some cases the salary given is the average for the several employees of the same designation.

The following comparison of European figures with the figures used in the above estimates for the raw materials used in the manufacture of cyanamid was presented by Mr. Geo. J. Roberts to show that his estimates are conservative:

Raw material required to manufacture 1 ton of calcium cyanamid.

Raw material.	British figures.[1]	United States Nitrate Plant No. 2 estimate.
	Tons.	*Tons.*
Limestone	1.36	1.75
Coal	.16-.24	.21
Anthracite or coke	.49	.54
Electrodes	.02	.019

[1] Taken from final report of British Nitrogen Products Committee, pp. 253-257.

Calcium cyanamid costs.

	European plant.[1]		United States Nitrate Plant No. 2.	
Limestone	1.205 tons, at $1.24	$1.48	1.75 tons, at $1.25	$2.19
Coal	0.154 ton, at $5.03	.77	0.21 ton, at $4	.84
Anthracite or coke	0.434 ton, at $5.03	2.16	0.54 ton, at $6	3.24
Electrodes	0.0192 ton, at $64.60	1.24	0.0189 ton, at $100	1.89

[1] Taken from document 115, British Nitrogen Products Committee.

The CHAIRMAN. Mr. Secretary, the committee is very much indebted to you and your staff. We will now adjourn until some future date.

(Whereupon, at 10.55 o'clock p. m., the committee adjourned to meet at the call of the chairman.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

THURSDAY, APRIL 8, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

The committee met pursuant to call in room 326, Senate Office Building, at 10 o'clock a. m., Senator Asle J. Gronna presiding.

Also present: Senators Gronna, (chairman), Wadsworth, Kendrick, Harrison, and Ransdell.

The Chairman. As I understand it Mr. Washburn wanted to be heard on Senate bill 3390, a bill introduced by Senator Wadsworth, which provides for an appropriation of $12,500,000 to continue the operation of the Muscle Shoals nitrate plant.

The committee was fortunate enough to have the Secretary of War here together with his staff of experts, who gave very valuable testimony. The chair has to apologize for not having that testimony printed, but it is not altogether my fault because plates had to be made, which, as you know, is a somewhat technical work. There were a good many plates that had to be made for illustrations, and that is why the printing of the hearings has been delayed. I was in hopes that we would have those hearings printed and ready for use to-day. I, however, have galley proofs, and if there is anything that you want to refer to, Mr. Washburn, these galley proofs will be at your disposal for anything that you wish to see.

Mr. Washburn. Thank you.

The Chairman. I think what the committee would like to know, Mr. Washburn—and of course you are at liberty to proceed in your own way—but speaking more particularly for myself what I would like to know is, whether you have made a personal inspection of this plant, and what you know about it, and what you have to recommend in connection with the matter. I know that you are an expert in this business. To me it is a technical matter and I have to depend on statements that are made by experts like yourself and the experts who appeared here on behalf of the War Department.

Now, Mr. Washburn, you may proceed in your own way and tell the committee what you know about nitrates, about these different processes, and give us any information that you care to give. Please give to the stenographer your name and official position.

STATEMENT OF MR. FRANK S. WASHBURN, PRESIDENT OF THE AMERICAN CYANAMID CO., AND OF THE AIR NITRATES CORPORATION, NEW YORK.

Mr. Washburn. Mr. Chairman and gentlemen of the committee, I want to thank you for the opportunity to appear before you on behalf of these interests that I represent. And I trust that by the time I am through those who represent other interests than my own will believe I have contributed something here that is of value.

The United States have a partner in these nitrate plants which are the basis of the bill you have just referred to and which this committee has under consideration, and that partner is the American Cyanamid Co., of which I am president; and the partnership is of a very unusual kind.

The War Industries Board and the Ordnance Department appealed to the American Cyanamid Co. in September, 1917, six months substantially after we had entered the war, to provide them with an escape from a situation which they assured me could only be provided for by a willingness of the staff of the American Cyanamid Co., in effect, to absolutely subscribe themselves to this governmental effort.

They had found, as other nations had found in this war, that it was impossible to provide explosives under the artillery program that had become a necessity in carrying out the type of war that was being waged and to secure those explosives from anything like the ordinary sources. There was a particular kind of material which must be had in enormous quantities, and there was only one source, and that was from the atmosphere, from which it could be secured, and there was only one organization in the United States that knew the first thing about fixation of atmospheric nitrogen. Outside of the staff of the American Cyanamid Co. there was no one who knew anything about it except what they could take out of literature as to secret processes, and all such literature, broadly speaking, was three years old in its development anyway.

There was a complete divorcement at this period, when the War Industries Board interested itself, from all previous relationships between the Government and the American Cyanamid Co. But that older situation had no place in the new; it was forgotten. It might just as well have been a new situation presented of a new plan.

That situation was simply this, as presented to me: That the General Staff had a plan for a great offensive to open in the spring of 1919. This involved putting, as nearly as I could learn, about 2,500,000 men on the fighting line at that time. No explosives were available for them and we were six months already in the war. The first representation that I made to the negotiators of the Government—and they were principally men then brought in by the Government from our great industries and banks—was that we did not want pay or compensation or what is called profit for anything that we might do; but that in the building of these great plants we inevitably would raise potential competitors to our industry after the war was over, and that we felt we had the right to protection against commercial competition from those plants.

The arrangement that was finally entered into has resulted in the American Cyanamid Co. and its subsidiary, the Air Nitrates Corporation—which latter corporation was merely organized for the purpose of being a tool to carry out the work of the American Cyanamid Co. for the Government—resulted in these two companies being absolutely without any profits; that after we have paid the special tax that is provided by the Federal tax law, and have paid those items of expense that we have been put to and which the Government can not in the nature of things pay us but which are always important items, and have paid the salaries of a very large number of important men that we furnished without cost to the Government at all—I say, after we have paid all these things on the face of the books at that point there is nothing left that is substantial. And that is wiped out a number of times by the incidental disadvantage of taking our regular staff away from our business and devoting themselves for something like a year and a half almost exclusively to this Government work.

And, gentlemen of the committee, the partnership has another peculiar relationship that has not any similarity to the work of a contractor for the Government, and that is this: We were constituted the agent of the Government, which agent was to select the sites, pay for them, design the plants, draw the plans, construct the plants, and operate them; and to do all the incidental things, which were extremely important and a very large part of our activities, such as housing the men, providing police, fire, and sanitary departments, an hospital, and all those things that must be provided in a place like Muscle Shoals, where there is a community suddenly built up of over 20,000 people.

There was no department of the Government that performed that work. I see the very natural expression every now and then, "plants built by the Ordnance Department." The Ordnance Department built no part of the Muscle Shoals plant. They knew nothing of the art, and did not practice it, and took no constructive or affirmative part in the situation whatsoever. The duties of any department or any individual connected with the Government with reference to the design, construction, and operation of that plant were those of an auditing character and of an inspection nature.

So much for what one might call the human aspect. But, after all, this relationship between the Government and the American Cyanamid Co. is covered by two contracts between the Government and the Cyanamid Co. and its subsidiary, the Air Nitrates Corporation. But the farthest thing from the thoughts of the negotiators of the Government when those contracts were made was that the Government would ever itself engage in merchandizing and manufacturing with these plants as a basis. The effort was made to protect the American Cyanamid Co. against competition in the future, and in such a way that the American Cyanamid Co. could not by any chance take advantage of the Government.

The CHAIRMAN. As I understand it, Mr. Washburn, you are still cooperating with the Government? That is, you are cooperating with them in this way, that the Government is using your patents, for which they pay you a royalty. Am I correct about that?

Mr. WASHBURN. Yes. If the Government ever operates the Muscle Shoals plant itself, which it has never done yet, because the operations have been performed by the Air Nitrates Corporation, it will be using the patents of the American Cyanamid Co. And there is no way of using those plants except in accordance with the specific rights, under specific patents, given by the American Cyanamid Co.

The CHAIRMAN. But as I understand it the Government now has a contract with the American Cyanamid Co. and are permitted to go ahead and use those patents?

Mr. WASHBURN. Yes.

The CHAIRMAN. All right. You may continue your statement.

Mr. WASHBURN. An analysis of the facts will bring you to the conclusion, I believe, that this particular bill is in natural sequence with the unhappy bungling that has characterized the Government's action every time it has been brought in touch with the nitrogen question, and that covers a good long period of years; of the efforts of the Government to place itself in touch with the situation. The problem before you is a question of fact, and it is my purpose to marshall the facts for you so simply and convincingly that they will carry largely their own interpretation. I want to leave to the least possible extent any necessity on your part to weigh contrary opinions and the motives of those who express them. Undoubtedly if you gentlemen are to listen here to a great many Government representatives, beginning with the Secretary of War, and then listen to me, one individual, on the other side, and form your ideas from the opinions that we may express, there will be but one conclusion, and quite properly so, and that would be the conclusion that the Government's representatives here are correct. But a very pertinent fact, a very sound, sensible business aspect of this case, is violated by the generalities which these gentlemen engage in. That is what I am going to prove to you before I get through if you will have the patience to follow me along.

Now, gentlemen of the committee, I think it is a proper thing in these circumstances that I should qualify as competent to appear before you in connection with this subject: My profession is that of the engineer. I have been pioneering in electrical, mining, and chemical engineering and in hydroelectric power and water development. I am either now or lately have been the president of a coal-mining company, a hydroelectric power company, a manufacturing company engaged in the production of electric-mining machinery, a chemical company and its subsidiaries—and all of them are among the largest and most important of their class in the United States. In substantially every case I conceived the project, gave it its engineering form and foundation, secured the capital for its development, and established it as a worthy, important, and prosperous industry. And I might add right here, there is not one of them that is not prosperous.

As president of the Air Nitrates Corporation I gave special, particular, and personal attention to the conduct and administration of that work, and for the Government we expended approximately $90,000,000. You know something of the quality of the work done and of the remarkably short time in which the Muscle Shoals nitrate plant was constructed, and I am going to refer to some factors in connection with it somewhat later.

The CHAIRMAN. The Air Nitrates Corporation is the one that operated at Muscle Shoals?

Mr. WASHBURN. Yes, sir.

The CHAIRMAN. You may proceed with your statement.

Mr. WASHBURN. I devised the first plan for the development of water power at Muscle Shoals on the Tennessee River, which in all essentials is the plan being followed by the Government to-day. The first investigations, surveys, studies, and purchases of dam sites for the construction of dams and the development of power at Muscle Shoals were made at my instance and under my direction. I have been a consistent and ardent pioneer and champion of the project for establishing the great industrial development on the Tennessee River contiguous to the great Birmingham coal and iron district of the South.

Now, gentlemen of the committee, I wonder if there is anyone who has any definite idea of what the Government hopes to accomplish by operating the Muscle Shoals plant? There is a hazy, wild, exaggerated statement of what is going to be done for the country for the farmers, but no business organization nor anything undertaken by the Government can live and be fruitful and worthy that does not subject itself to an analysis of the details. For, after all, it is the details that apply in a case of this kind. I am going to raise some of these questions.

In the first place, it has been represented that it is very desirable, inasmuch as the Government has expended $75,000,000 in the construction of a plant that it should make use of it. Well, the Government did not expend $75,000,000 on the plant. Our books show that after deducting salvage for materials, and after deducting returns on commissaries and things of that kind, the net amount of money expended by us on that plant represents $62,303,062.07, or in round figures we will call it $62,300,000. There was in addition a 30,000 kilowatt auxiliary power plant constructed.

But this actually much smaller amount is not significant of what the Government hoped to put into use in the way of operations there, because the cost of that part of the plant which the Government proposes to use down there after loading it with all the auxiliary expense, overhead and everything else, is only $33,000,000. The normal replacement cost to private interests would be $15,000,000. Now the Government either is expending or proposes to expend $38,000,000 in order to make use of a property which cost it $33,000,000, and which my company, for instance, could replace to-day just as good and effectively for $15,000,000. That I take it, gentlemen of the committee, is a very different aspect from the way this thing has ever been presented.

The CHAIRMAN. Will you restate that, please?

Mr. WASHBURN. The statement is that the Government is expending or is preparing to invest $38,000,000 in order to make use of a property which cost it $33,000,000, and which could be replaced under normal conditions by private capital for $15,000,000.

Senator KENDRICK. Do you mean to say that the Government would not employ all the property that had been developed there under war conditions in this manufacturing establishment?

Mr. WASHBURN. Yes.

Senator KENDRICK. What part of it would they not employ?

Mr. WASHBURN. They would not emply the steam-power plant. They propose to replace that with water power.

Senator KENDRICK. Yes; but we were told here they expected to use that for emergency purposes when their supply of water was low and their power was reduced on that account. Wouldn't it be necessary after they had the power plant in working order, if that were true to-day, to have this other plant to reinforce the water-power plant?

Mr. WASHBURN. No, sir.

Senator KENDRICK. To have some sort of steam or other plant that they could fall back on in case of necessity?

Mr. WASHBURN. There is all the power plant there now that is necessary to operate the Muscle Shoals plant in the way of steam. It was sufficient under the exigencies of war and is sufficient now;

and it will cost the Government no more to use that steam plant; that is, the power will cost the Government no more than by expending another $25,000,000 in order to use water power.

That subject I will come to later on as a matter of definite proof. I thought I would just sketch over these broad features first, if that is agreeable to you.

Senator KENDRICK. Certainly.

Mr. WASHBURN. Certainly the Government does not want to run the Muscle Shoals plant if it can not produce the product which it is their purpose to produce, namely, sulphate of ammonia, cheaply enough to get into the market with it. I expect to convince you that the Government could produce it down there only very expensively and substantially at a loss to the Government. There is a large element of proof involved in that matter, and I may just for the moment say, in order that you may have some confidence in our judgment on such things because we have had a very large plant for the production of sulphate of ammonia by the cyanamid process, that we have abandoned it completely, and we abandoned it because we could not make sulphate of ammonia and stay in the market with it and use cyanamid as a raw material.

The CHAIRMAN. Who do you have to compete with now in the markets?

Mr. WASHBURN. We compete with the by-product ammonia from the iron and steel industry.

The CHAIRMAN. All right.

Mr. WASHBURN. Another thing that has been stated here is that the farmer is going to be helped. The whole proposition of these gentlemen is that operating the plant is going to be some great use and benefit to agriculture. The farmers have been told that the administration plan will give them cheaper fertilizer. I say to you gentlemen that the farmer will gain absolutely nothing under the Administration plan. I am going to analyze that for you, and among other things it may come to the point, and I assure you I would welcome it very much, that I will actually face some of the gentlemen who have come here urging that there are great benefits to come to the farmer from the Government plan. I would like to have them face me and show you where the farmer is going to get anything out of this. But I will come to that later in my analysis of the matter.

In order that you may have a test of this thing, I have here two tubes (Plate I), superimposed one upon the other, containing fertilizer materials that the farmers of this country use, and the amounts are in proportion to the cost of those materials. Here are nitrate of of soda, sulphate of ammonia, cyanamid, animal tankage, and miscellaneous organic materials. Here are acid phosphate and potash. There are so many dollars in this material and so many dollars in that. This is sulphate of ammonia, which is the average value between the years 1912 to 1917. This is what the Government proposes to make, that material in there.

The CHAIRMAN. What percentage of the whole amount does that represent?

Mr. WASHBURN. Nine per cent. Now, the Government, by making sulphate of ammonia as a direct product and competing against the by-product ammonia that must be produced anyway, is going to save the farmers of this country in handling and selling a

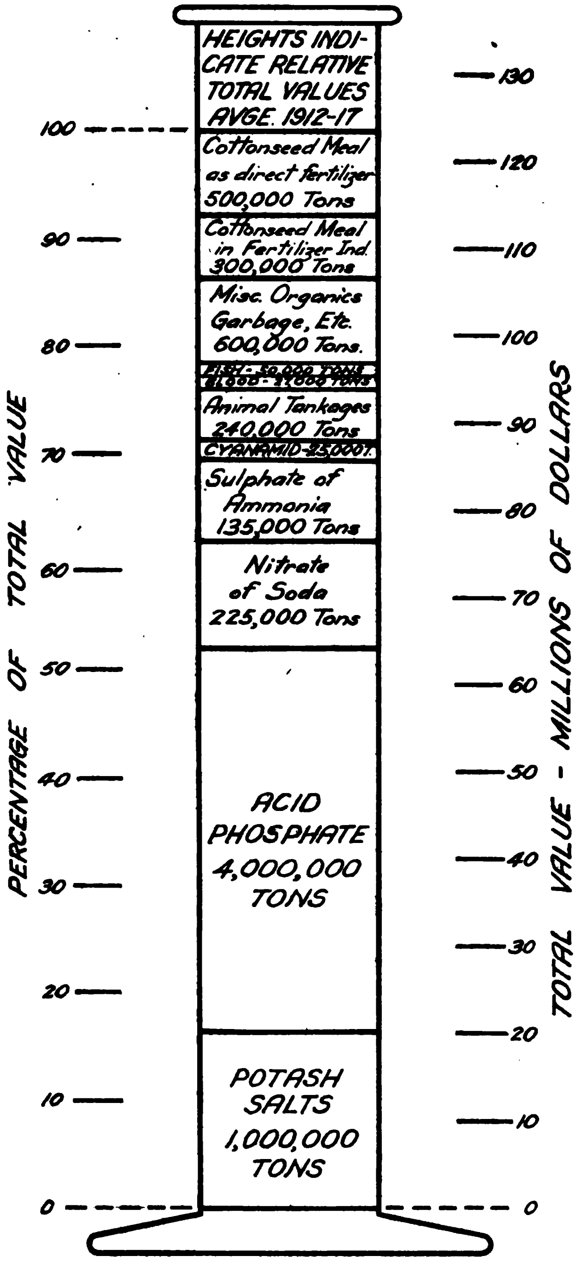

HEIGHTS INDICATE RELATIVE TOTAL VALUES AVGE. 1912-17
Cottonseed Meal as direct fertilizer 500,000 Tons
Cottonseed Meal in Fertilizer Ind. 300,000 Tons
Misc. Organics Garbage, Etc. 600,000 Tons.
FISH - 50,000 TONS
BLOOD - 27,000 TONS
Animal Tankages 240,000 Tons
CYANAMID-25,000 T.
Sulphate of Ammonia 135,000 Tons
Nitrate of Soda 225,000 Tons
ACID PHOSPHATE 4,000,000 TONS
POTASH SALTS 1,000,000 TONS
PERCENTAGE OF TOTAL VALUE
0
10
20
30
40
50
60
70
80
90
100
TOTAL VALUE - MILLIONS OF DOLLARS
0
10
20
30
40
50
60
70
80
90
100
110
120
130

PLATE I

product that represents merely 9 per cent of the fertilizer expenditure that the farmers make. I am going to show just what that means on the farm and just what it means to the fertilizer manufacturer later.

The statement has been made that the administration can dispose of 150,000 tons of its present store of Chilean nitrate of soda and devote the proceeds, which they trust or hope will amount to $12,500,000, to a fixed investment in one thing and another at Muscle Shoals. If there is any situation which requires this Government at this time, as we sit here, to hold in storage 150,000 or 300,000 tons of Chilean nitrate—and personally I should think they ought to have a great deal more—but if that situation actually exists, I do not know of any way, because our organization has been working every day, whereby the operation of the Muscle Shoals plants would warrant them in making disposal of substantially any part of what they now have in store. The reasons for that I will come to later. I am merely now covering the ground I hope to elucidate.

Another thing that has gone through the press of the country is that the operation of the Muscle Shoals plant will tend to lessen the tax paid to Chile and the quantity of Chilean nitrate that is used and relieve the farmer from his dependence upon Chilean nitrate. Now, the fact is that if the administration plan should result in their being able to force this additional quantity of sulphate of ammonia on the market it could only result in one way, and that is to increase the amount of Chilean nitrate that is used and therefore increase the dependence of the farmer on Chilean nitrate. There is no other way out of it. But that I am coming to later.

There have been most extraordinary forecasts of a shortage of nitrogen, and that, too, when before the eyes of all the people in my industry, including my foreign associates—and I spent four months of the summer of last year with them on the other side—the one striking thing before us that has come out of this war is the enormous surplus of ammonia nitrogen producing capacity in the world and in the United States. It is the thing that frightens all of the cyanamid companies. How are we going to sell as manufacturers all the ammonia that can be produced in the world?

There was a chart, to which I will refer later, that appeared in one of the technical journals showing that there was a shortage of material which could be filled by the Muscle Shoals output. Why, gentlemen of the committee, there is an enormous overplus without the Muscle Shoals plant. And when you run the Muscle Shoals plant you load its output on top of all that surplus. And I will give you definite proof of that situation. Not only will I give you proof, but I will use this chart prepared by a former officer of the Ordnance Department—because what I want is a head-on collision with the Administration's people—and show you the truth of this situation. I am going to take this very chart, and I am going to build upon it an absolutely different conclusion from the one which was reached, and a conclusion that the whole world knows to be correct, namely, that there is this enormous capacity for production of ammonia nitrogen.

Senator KENDRICK. Do you mean to say that there is a quantity of nitrogen on hand now or that there are possibilities of production?

Mr. WASHBURN. There is seldom any sulphate of ammonia on hand in any great quantity, under normal conditions, but there is the capacity to produce.

Senator **Kendrick**. In the manufacturing establishments that are now under way and in course of production.

Mr. **Washburn**. Yes, sir. Some of them are under construction. But with the exception of a very few by-product ovens, they are all completed and have capacity for production.

It has also been represented that it is necessary to operate this Muscle Shoals plant in order to preserve it from deterioration. I do not exactly see the consistency of that claim for the reason that inevitably the Government plan will result in shutting down and holding in idleness the very part of the equipment which they have stressed most, namely, the electrical equipment. But, however, it is our judgment, after years of use of identical equipment and which we know how to take care of, that it can be held in idleness without deterioration. We know that the operation of the plant as a whole would bring greater deterioration than to hold it in idleness. I do not know that it is important, but if it should be accepted by those in authority that it is necessary to run that plant to keep it from deterioration it would be of importance, but that is not the case.

There are some details here I might as well mention because they show a tendency I may want to deal with later, but it is not the kind of thing I am stressing at all. I am not attempting to present to you anything except those matters that are properly in the interest of the people of the United States. But one of the things that are properly in the interest of the people of the United States and of you gentlemen as the representatives of those people is that there shall be justicw and fairness in dealing with the citizens. That is far more important than running any kind of plant or any economic problem and its solution. There is so evidently a spirit on the part of some of those connected with the administration to be absolutely unfair to this company, that even though I am not stressing it and do not ultimately fear its consequences, I think it fair to refer to it. One of the things is that the Government may be permitted to produce cyanamid fertilizer. They do not expect to do it, they say, but they can do it. This the Government can not do. The rights of the Government for manufacturing at Muscle Shoals are only the rights delegated to it by the American Cyanamid Co. The patents under which rights are given are specifically set forth in the agreement with the Government and do not include the patents covering either the manufacture or the use of cyanamid fertilizer.

The **Chairman**. When you say "this they can not do," what do you mean by it?

Mr. **Washburn**. I mean that they can not do it in the same sense that no private party could build a plant or take an old one and proceed to make cyanamid fertilizer. They have not the patent rights, and it was never intended that they should have them. Those patent rights are our means of protection and perfectly proper means. That plant was not built to make cyanamid fertilizer; it was built to make explosives.

The **Chairman**. In other words, just so that I may understand it, and I may be somewhat obtuse, but let me ask: I understand you to say that while you permitted the Government to use your patents during the war for the manufacture of nitrates to carry on the war, which, of course, was absolutely necessary, yet the contract that you have with the Government does not go to the extent of permitting the Government to manufacture for any other purpose other than the manufacture of war materials?

Mr. WASHBURN. It is not quite that. I can state it very clearly to you.

The CHAIRMAN. I wish you would.

Mr. WASHBURN. The Government can make the chemical material which carries the name of calcium cyanamide or lime nitrogen. From that point they can make ammonia. That is covered by our patents. From that point they can make oxides of ammonia and can make weak nitric acid, which is covered by our patents. And then that is mixed with some ammonia made from the lime nitrogen and we have nitrate of ammonia. But cyanamide fertilizer is not lime nitrogen. And lime nitrogen or calcium cyanamide is not cyanamide fertilizer. We take that raw material of lime nitrogen, which the Government is allowed to make, and we make of that cyanamide fertilizer. The Government has no right to make that fertilizer. And there are additional processes in there which the Government has not the right to use and which it was never intended it should have.

Senator KENDRICK. That is a matter which could be settled in the courts, as to their rights.

Mr. WASHBURN. Well, I do not think it is a court matter because it is perfectly clear on the face of the contract. The statement is made, substantially speaking, that our patents are not good for anything. That is absolutely contrary to our understanding. We have never had our patents questioned before, except at one of the hearings here. In any event, whether that patent is good or bad, and we have never known but what it was perfectly sound, there are a number of patents in there controlling it, and it was never intended that one of the materials the Government could make would be cyanamide fertilizer. So the inherent justice of the thing outside of any discussion of the validity of the patents is violated if the Government goes into the manufacture of cynanamide fertilizer.

Senator KENDRICK. May I ask for how long a time your patents run?

Mr. WASHBURN. Yes; the controlling patents run to 1932.

The CHAIRMAN. I did not intend to raise a legal question by the question I asked you. I just wanted to know what the plain understanding was as to how far your contract actually goes.

Mr. WASHBURN. All right.

The CHAIRMAN. You may continue your statement.

Mr. WASHBURN. I have some knowledge of the antecedents of this present Muscle Shoals situation. I think they would be useful to you and I will sketch them over pretty rapidly. There are no special points to stress, but I will just give you a panorama of it because I think it right important for you to have it.

The CHAIRMAN. The committee will be very glad to have it.

Mr. WASHBURN. The nitrogen fixation industry was introduced to the western hemisphere by me in 1907. An experimental plant of commercial size was built in Canada at Niagara Falls where the cheapest available power was to be had. The first product was delivered to the consumer in 1910. The success of this venture prepared the way for the erection of a much larger plant in the United States. To this end permission was asked of the Congress for the erection of a dam across the Coosa River in Alabama. Four million dollars was available for the initial nitrogen fixation plant in the United States. We were attacked with a perfect whirlwind of prejudice and accusations by the socalled "Conservationists," who held sway in those days. The "pernicious Coosa River bill" became anathema. We were classed with traitors and thieves, accused of harboring designs for creating a great atmospheric and water-power trust. This was in 1912, when the country had available a wholly inadequate supply of nitrogen—our production of by-product ammonia being the equivalent of only 165,000 tons sulphate of ammonia, and the importations one-half times as much. Here was the opportunity for nitrogen fixation that every other civilized nation had striven to provide for itself and had for the most part succeeded. There was offered here what other countries were honoring certain of their citizens to secure. Congress passed the bill, only to have it vetoed. The power site stands undeveloped as it was in 1912 in the wilds of Alabama, miles from any habitation, just as the Indian left it in 1836. The industry was held in such low esteem as to be denied admittance to the country by administrative blundering at a time when it was needed.

Time has shown that we were not unpatriotic or grasping or undesirable citizens in any sense in our desire to enter this country with the nitrogen fixation process down in the wilds of Alabama. That thing was held on us as a crime for years, whereas we all know it simply represented a pioneering spirit on the part of a very simple group of American citizens. But we were not recognized as such then.

Beginning as early as 1906, as president of the Muscle Shoals Hydro-Electric Power Co., I began efforts with the War Department and the Congress to secure permission to develop power at Muscle Shoals on the Tennessee River in northern Alabama. Government cooperation was sought to the extent of its paying for the navigation locks and one-half of the power and navigation dam. After many modifications and with ever-growing friendliness to the project on the part of the Engineer Corps, United States Army, the Board of Engineers for Rivers and Harbors recommended in 1916 the acceptance of the competitive proposal made the Government by the Muscle Shoals Hydro-Electric Power Co. That proposition was made in 1914, but it was 1916 before the board of review recommended its acceptance. That offer proposed that the United States construct locks, Dams 2 and 3—one dam being approximately 100 feet high and the other one approximately 40 feet high—and power house substructures, and the company construct the power house superstructures, build and install all hydro-electric equipment, transmission lines, substations, distribution lines, etc. The company was to contribute $3,000,000 cash to the Government for defraying the expense of its part of the job, and was to make annual payments of fixed amounts and a royalty per horsepower of installed capacity on 100-year lease. The result, based on the anticipated rate of marketing power, would have been that at the end of the lease period the Government, still in possession of all the dams, locks, and powerhouse substructures, would have had repaid to it their full cost, together with interest. The anticipated total expenditures of the company for carrying its part was $80,000,000.

The recommendations of the Engineer Board were never acted upon, either by the Secretary of War or by the Congress.

That is simply a brief history of Muscle Shoals. I think there is no citizen of the United States familiar with the facts who does not regret that the Government failed to accept our proposition.

Various departments of the Government in the summer of 1915, followed by certain congressional committees, invited the assistance of me and my company in the formulation of some plan by which the Government might safeguard itself by having an internal source of nitrogen supply in case of war. Out of this invitation eventually grew our recommendation for cooperation between the Government and private interests under which a nitrate plant was to be built at Muscle Shoals and operated by the American Cyanamid Co. The Government was to invest $20,000,000 in hydroelectric power plant and such portions of the chemical plant as would be required exclusively for the processing of military explosives. The company was to provide $24,000,000 for a cyanamid and fertilizer plant and for working capital and was to rent power from the Government at a rate profitable to the Government. In times of peace the company was to conduct its business in the ordinary way by the operation of the cyanamid and fertilizer plant and was to keep the whole plant in readiness to turn into the manufacture of military explosives on short notice. At the command of the Government the company was to devote the whole plant to the production of explosives by the regular staff of employees and receive such compensation as the Secretary of War might deem proper.

Out of this grew the "nitrate supply" section (124) of the national defense act approved June 3, 1916——

The CHAIRMAN (interposing). Are you reading now the provisions of the contract?

Mr. WASHBURN. No, sir; I am merely giving you the history of what precedes the construction of this present plant at Muscle Shoals and largely for the purpose of having you understand what our relationship to this situation is and particularly to show you the complete cutting off of all those things that went before from the situation as it is to-day.

The CHAIRMAN. Those were all tentative agreements which did not materialize?

Mr. WASHBURN. Yes; those did not materialize. I came before the committee at that time at your invitation, if you will remember.

The CHAIRMAN. Yes.

Mr. WASHBURN. Out of this grew the "nitrate supply" section (124) of the national defense act approved June 3, 1916, appropriating $20,000,000 for establishing a nitrate supply, but with the amendment tacked on that the "plant or plants provided for under this act shall be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital."

Now, there is a belief in some quarters that this present plant at Muscle Shoals was built under that act and from funds that were appropriated by that act. But that is not the case. I believe, as a matter of fact, that the land was purchased from this appropriation, some two thousand three hundred and sixty-odd acres; but that is the full extent of any moneys taken out of that appropriation for the Muscle Shoals plant. That $20,000,000 went into the construction of this Muscle Shoals Dam, as I understand it.

As a result of confidential information secured through our connections abroad as to the difficulties which our allies in Europe were encountering in meeting the demand for explosives necessitated by the tremendously expanded artillery program I addressed a letter to the Ordnance Department on April 16, 1917, advising that a solution of the difficulties had been found in the successful development of a new and powerful shell explosive. At an interview with the ordnance expert assigned for the purpose our studies and recommendations were developed. We presented two conclusions; first, that if our country should be drawn into the war as early as the 1st of January, 1918, immediate steps must be taken to provide for the manufacture of nitrate of ammonia, otherwise we could not place a respectable sized force in the field with the requisite artillery; and, second, that there was no way in which anything more than a very small and wholly inadequate quantity of ammonium nitrate could be provided except by the cyanamid process. In due course I received a letter stating that the Ordnance Department would prefer to confine our troops to the use of the old-fashioned nitrate powder with which it was familiar, so long as it could be obtained in sufficient quantities.

It is not conceivable to me that the Ordnance Department did not know a great deal more about that situation than I did; but we did have sources of information which on a number of occasions have proven superior, and it was a very natural thing for me if I knew anything coming from such sources to convey it to the Government. I do not mention it as any question of criticism of the Ordnance Department whatsoever, but I want to bring out that in everything we have ever done in connection with this Government time has shown it was a creditable performance, or at least not discreditable. That thing came to be absolutely true as you will see, because six months later we were begged to come to Washington and build something for them to take care of the ammonium nitrate situation, the same material that is recommended here; but what I am going to relate now I want to make particularly impressive for the reason that it is difficult for anyone, as I found it difficult myself, to realize how little the scientific world in America knows about the fixation of atmospheric nitrogen. When I go back over the years of the struggle of the particular and exclusive organizations that have operated in connection with fixation of atmospheric nitrogen, it develops that the man who merely reads can not by any possibility transform that mental picture or that purely intellectual conception of it into practical effect. He fails over and over and over, and you will see that that was true in what I am now going to relate.

President Wilson, shortly after the passage of the national defense act of June 3, 1916, in accordance with provisions empowering him to make investigations, arranged for the appointment of a committee consisting of nine scientists and engineers—

> to determine the best, cheapest, and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products.

Later this committee, after making a report regarding which there is no public information and which may have recommended the cyanamid process, was succeeded and its work continued by a new committee appointed by the Secretary of War and known as the nitrate supply committee. This was composed of 5 members of the original committee, the Chiefs of Ordnance of the Army and Navy, the Chief of Engineers, and 3 representatives from departmental bureaus, making a total of 11 members.

Now, gentlemen of the committee, I would like to emphasize the constitution of that board. If you were going to accept their advice or opinion, and I do not know whether you are, where would you get a board whose opinion would be more convincing? I want to show you what they ran into.

On May 11, 1917, substantially one year after the passage of the national defense act and one month after we declared war upon Germany and almost as much as that after the appointment of the committee, this committee recommended an expenditure of $3,000,000 out of the $20,000,000 nitrate supply appropriation for the purpose of experimenting with a new, undeveloped, untried nitrogen fixation process which had been brought to the attention of the committee.

Senator WADSWORTH. What process is that?

Mr. WASHBURN. A modification of the Haber process.

Senator WADSWORTH. All right.

Mr. WASHBURN. An additional million dollars was recommended for the purpose of carrying out further experimentation with a number of other new processes and with the same object in view. Any extensive installation of nitrogen fixation processes and water power development in connection therewith was to be postponed until the experimental plant had given results.

There we had been a month in the war and they said don't spend any more money until you get through experimenting, or, in their own language, "until further need arises." Months before I had represented to the Ordnance Department, and the Ordnance Department must have known it without our representations, that we were in danger of a situation where we could not put forces in the field because we could not have explosives. And yet this magnificant committee, as it was when you consider its constitution, says, "let us experiment and not spend any money."

Senator KENDRICK. They did just the other thing from what the Aviation Department did; in aviation they spent money and did not experiment.

Mr. WASHBURN. And it does not seem to make much difference what method is employed, Government operation seems to find the same result in the end.

In September, 1917, six months after we had entered the war, the Ordnance Department in defense of the committee of nitrate supply caused its report to be published. Six months after we were in the war, mind you, that report was published as a defense of that committee, showing still the faith that they ought to operate with something new. This report seems to have been concurred in by the interdepartmental board appointed by the President to represent him and composed of the Secretaries of the War, Navy, and Agriculture.

The Government followed the committee's recommendations and expended substantially $13,000,000 in an unsuccessful attempt either to take it out of the purely experimental field or bring it to a producing stage.

Everything possible was done by me to deter the committee in its campaign of experimentation in the face of the enemy, but it was possessed with the hope of developing future economies in manufacture, notwithstanding that such a consideration would appear to be wholly unimportant under the circumstances and that, furthermore, there was no reasonable basis for anticipating that such economies could be secured, nor was there any real demand for them in the face of the exceptionally low manufacturing costs by the cyanamid process. A comprehensive review of the art of the "nitrogen industry" was prepared and presented to the committee upon the request of the chairman, including an analysis of the various fixation processes. That the cyanamid process was the only one which by any possibility could be relied upon to meet the situation confronting the United States was demonstrated beyond a question of reasonable doubt. As proof of our contentions every original record, account and bit of information possessed by our company bearing upon the questions at issue were thrown open to the committee and to anybody that they chose to send in there who was a respectable citizen to make an investigation. This offer was never accepted, although the committee's representatives who spent months abroad interviewed those connected with our associated cyanamid companies in Europe; my own personal associates, those I have reciprocal contracts with in connection with our patents. They went over to Europe and asked questions there and formed their judgment and would not go into the records of the American Cyanamid Co. for proof of the facts that we laid before them, facts that are admitted to-day and more than admitted.

That was the end of our enthusiasm and effort to do anything with this Government. And I think you gentlemen will feel it is not surprising. I do not know of anything that astonished me more or discouraged me more than the wind-up of our efforts to do something with the Government in the cyanamid process. And that is the record to show it to-day.

The CHAIRMAN. And the fact is that the only practical process that is available is the cyanamid process, in America I mean?

Mr. WASHBURN. New processes, Mr. Chairman, may be developed any day that are superior to the cyanamid process. We are not devoted to the cyanamid process just because it is the cyanamid process. We are a great chemical manufacturing concern along certain lines, and we want cheap nitrogen, and whenever we see a chance to get it we go for it. We have had an opportunity to acquire the Haber process but have never seen our way clear to use it because it is not as economical as the cyanamid process. But the General Chemical Co. or some other company may produce a process superior to the cyanamid process. But certainly when you are facing the enemy and months in a war you do not want to stop and go to work experimenting with processes that even now those gentlemen who have been at work on them are inclined to believe can not be carried to a large commercial development until something like 1930.

Now here begins a new phase as if we had wiped everything off the slate: The Ordnance Department and the War Industries Board sent for me in September, 1917, the same month in which the former published the report of the nitrate supply committee, and requested the American Cyanamid Co. to undertake the construction and operation of plants for the production of nitrate of ammonia. This was the result of advice received from ordnance experts sent to Washington from the allied governments. This is the material brought to the attention of our Ordnance Department, as heretofore stated, at the time of our entrance upon the war, nearly six months before. It was represented to me that unless the Cyanamid Co. could and would provide the plants and produce material within 12 months that the plans for placing a great fighting force on the battle line in France for the spring offensive of 1919 could not be carried out.

Agreements were consummated the 3d day of December, 1917, bearing date of the 16th of November, 1917, and later replaced by other contracts under date of June 8, 1918, under which the Muscle Shoals plant was built and operated under a subsidiary company of and by the staff of the American Cyanamid Co. Two more plants were under construction when the armistice was signed. Approximately $90,000,000 was expended for the Government; approximately $62,000,000 net for the Muscle Shoals plant. There was no material dishonesty; by that I mean no organized dishonesty. Our own police department prosecuted some 50 cases, and got convictions, but there was no material dishonesty or extravagance or avoidable waste.

The CHAIRMAN. In the expenditure of the $90,000,000, you have reference to plants 1 and 2?

Mr. WASHBURN. Plants 2, 3, and 4.

Manufacturing operations began eight months and eight days after the first foundation was laid. The capacity of the plant, the economy in power consumption, the low cost and purity of the product, and the limited period of construction all surpassed expectation. There was a 100 per cent result in every particular. Had the Muscle Shoals plant been operated for the three years contemplated in the agreement, based on the proven costs during the period of its actual operation, the Government would have been saved in comparison with the costs of the product from other sources, the entire cost of the plant and $20,000,000 in addition thereto.

The contracts between the Government on the one hand and the American Cyanamid Co. and the Air Nitrates Corporation on the other, covering the construction and operations of the Muscle Shoals plant, are controlling factors in fixing the future of that plant and should be the determining influence on the recommendation to be made by this committee. An understanding of those contracts on your part is therefore essential. To begin with, the American Cyanamid Co. offered to design, construct, and operate the plant, and furnish for this purpose substantially its entire executive staff of 10 or a dozen persons, without compensation, either direct or as royalties. We asked only that our industry, built up as a result of years of severe effort and at great expense, should be reasonably safeguarded from competition by these great plants upon the return of peace.

I might say that ex-Justice Charles Evans Hughes was our advisory attorney in our relations to the Government; in many of the things, but not always, we proceeded under his advice.

Now, these contracts provided—I will give a very short summary:

First. That the Air Nitrates Corporation, a subsidiary of and owned exclusively by the American Cyanamid Co., shall select the plant sites, purchase them, design, construct, and operate the plants; deliver the product to the Government in cars at the plant site. As a matter of fact, and in accordance with the intent and provisions of the contract, the Muscle Shoals plant was designed, built, and operated exclusively by and under the direction of the Air Nitrates Corporation; and no department of the Government nor anyone connected with such departments had any constructive relationship to the building or operating of the plant proper, or the public utilities, hospitals, police and fire departments, commissaries and stores, or the temporary and permanent housing of the employees. The knowledge of any of these arts on the part of Government officials and employees is only such as auditing, observing, and inspecting might give them. Of experience they had had none.

Second. The plants are to be operated on an operating fee of one-fourth of 1 cent per pound ammonium nitrate until the 1st of June, 1921.

Third. After the 1st of June, 1921, the plant can not be sold by the Government until the Air Nitrates Corporation has had the opportunity and a reasonable time to accept as favorable terms as the Government is willing to accept therefor.

Fourth. Now, the Air Nitrates Corporation performed this work on the basis of a percentage compensation, with a limit of a million and a half dollars, as I have already stated to you; and when the Government shall have paid us the full fee and when we shall have paid our taxes and our losses and our expenditures that the Government can not cover, and the many things we agreed to furnish without compensation from the Government, there is nothing left. And you can see, under any circumstances, there could not be. Our taxes are 86 per cent.

The CHAIRMAN. Would that mean that you have a preference right to purchase under your contract?

Mr. WASHBURN. It means that we have a right to purchase that plant under as favorable terms—and this is the language—"as the Government is willing to accept" for it.

The CHAIRMAN. Well, that would mean a preference right?

Mr. WASHBURN. Yes; I suppose that the direction that a thing of that kind would take would be that if the Government wished to sell the plant it would give the opportunity to the Air Nitrates Corporation to purchase it at the terms that the Government was willing to accept and if the Air Nitrates Corporation did not purchase it, it would dispose of it to somebody else. It does not seem to be much of a handicap to the Government.

The CHAIRMAN. Because you cooperated with the Government and helped to set it up you wanted, in return for that great assistance, the right to purchase it?

Mr. WASHBURN. We wanted as much of an opportunity as possibly could be provided for protecting ourselves from competition by the Government.

The CHAIRMAN. Certainly.

Mr. WASHBURN. Fifth. The Government acknowledges the ownership of the patents by the American Cyanamid Co., and that company licenses the operation of the plants, under specific patents indicated by number, date, and title. The company's patents covering the manufacture and use of cyanamid fertilizer, phosphoric acid or any of its processes, including the electric furnace phosphate process and ammonium phosphate, are not included in those for which rights are given.

Senator KENDRICK. I think it would be interesting, Mr. Washburn, it would be to me, at least, to know if you have had any negotiations with the Government, with regard to the purchase of this plant?

Mr. WASHBURN. No; no negotiations. We have given the matter a great deal of thought and have discussed the situation with Mr. Glasgow many months ago when he was in the country, and nothing has ever come of it. The difficulty at the moment is to find any way of making commercial use of that plant at this time, and that I am going into later in this analysis. Really what I have been giving you here is an introduction.

Senator KENDRICK. But you have not made the Government any offer for it?

Mr. WASHBURN. No; none whatever.

The CHAIRMAN. Would the Government officials have authority to sell without further congressional action; without further legislation?

Mr. WASHBURN. That I do not know, Mr. Chairman.

Sixth and the last thing. The American Cyanamid Co. is to receive royalties at the one rate before the 1st of June, 1921, and at another rate afterwards; it is to receive a royalty per unit of nitrogen produced of six-tenths of 1 cent per pound of nitrogen to June 1, 1921, and 1½ cents thereafter; but should either party become dissatisfied after the 1st of June, 1921, with the 1½ cents fixed he may appeal to arbitration.

I have already related to you the nature of the negotiations, and that I believed it to be the purpose of the negotiators on the part of the Government to go just as far as they could to save these great plants becoming the engines of our own destruction. And when you consider the bald fact that as we stand here to-day everything we received from the Government has profited us nothing—and of that we do not complain; that is as we wanted it. I have letters here addressed to the Government showing that we did not want any profit; but we did want protection after the war was over. And now the Government itself proposes to go into competition with us, and whatever the incentive, it is suggested by the gentlemen who have charge of this that they shall make cyanamide and sell it to our customers.

Senator KENDRICK. Basing the assumption always on the proposition that you are properly protected on your patent rights and that sort of thing, you would not contend that the Government should not do what it could to bring about a system of competitive production of as necessary a product as the fertilizers of the soil; you would not want a monopoly of that production?

Mr. WASHBURN. Absolutely not. No, sir.

Senator KENDRICK. Then just how far would you expect them to go to protect you against competition?

Mr. WASHBURN. I would not expect the Government to undertake any positive action to save us from competition; never have asked it and do not expect it, except in so far as is involved in carrying out the contract with this company; and except in so far as is involved in the Government going into the production of the material against the cost of which they charge no taxes, no interest, no depreciation. The

Government engaged in any industry can, I believe, ruin everybody else connected with the industry.

Senator KENDRICK. I suppose you know that this committee particularly has been bombarded with the statements that the Government could not do anything?

Mr. WASHBURN. Yes; and in the sense in which those comments were made I imagine there is a good deal of foundation for it, but in the sense that a plant like the Muscle Shoals plant could be run without the necessity for profit and without charging as costs those items which all of the citizens of the country and all of the taxpayers have to include in their costs and with the inducements all the time on the part of a great body of people who would be benefited by receiving that material cheaply, I should say the threat against the other industries engaged in the production of ammonia would be very, very serious.

Senator KENDRICK. I do not want to break the line of your statement, Mr. Washburn; I thought that was an important point or question, how far you would expect the Government to go in preventing competition.

Mr. WASHBURN. I am glad you raised it, because I do not want, myself, to be understood as coming here and asking for anything more than a fair deal under our contract.

The CHAIRMAN. There is always a complaint from the farmers that things are high, and I think there is more complaint at this particular time as to the price of fertilizer. If this is not a proper question you do not need to answer it, but I would like to know what is the American Cyanamid Co. receiving per unit or per ton for cyanamide at the present time?

Mr. WASHBURN. It is receiving $3.50 to $4 a unit. Sulphate of ammonia, the price has just been fixed as $4.50 in bulk, but there is an additional price to that for bags—additional cost, but the Cyanamid Co. is selling its cyanamid cheaper than sulphate of ammonia is being sold for, and that has been its custom for years; it is the cheapest form of nitrogen per pound in the market.

The CHAIRMAN. Does the Cyanamid Co. produce a sufficient amount now, at the present time, to supply the needs for fertilizer?

Mr. WASHBURN. Just about, so far as cyanamide is concerned.

The CHAIRMAN. What proportion of it goes into fertilizer consumption?

Mr. WASHBURN. Of total nitrogen compounds produced, 91 per cent goes into fertilizer. The cyanamide going into fertilizer represents 57 per cent of our total possible output.

The negotiators of these agreements on both sides scouted the idea that our Government would ever seriously propose to operate these plants as peace-time producers of commercial articles and go into trade. I trust the fact will be clear to you that their one thought as to the future was to arrange for peace-time operation so that the American Cyanamid Co. might be able to protect itself against annihilation by the engine of destruction it was obliged to create in order to arm the Nation for the supremest effort in its history, while at the same time safeguarding the Government against the imposition of unreasonable terms.

Thus it happens that the United States of America among other war salvage such as battleships, fortifications, shipyards, explosive plants, owns a plant in north Alabama, built to produce nitrate of ammonia and capable, with an additional investment of some millions of dollars, of producing the nitrogenous fertilizer, sulphate of ammonia. Now after years of implacable antagonism to the gaining of a foothold in this country by the nitrogen industry, our Government suddenly concludes that the immediate establishment of the nitrogen industry on a perfectly huge scale is so vital to the country that only through another experiment can it be properly conserved. The brand new and untried experiment of the Government entering the commercial field of manufacturing and selling an ordinary article of trade is proposed.

Now, no useful purpose would be subserved in operating the Muscle Shoals unless the product were in demand. A wise manufacturer and merchant before putting a product on the market must be abundantly satisfied of a demand for it. The administration, in the studies which it has presented to you, deals with nitrogen en masse, which leads to the wholly false proposition that the whole field of nitrogen uses can be invaded and filled by one kind of nitrogen to the exclusion of all other kinds. A coat, a vest, and a pair of trousers constitute clothing, but if the Government should start a coat factory, it would make no difference how many nor how cheaply it could make coats; it could not, with propriety at least, expect to drive out the use of trousers.

The CHAIRMAN. You come in competition with the Chilean nitrates, do you not?

Mr. WASHBURN. Yes and no; Mr. Chairman. Chilean nitrate is to be sold at a comparable price, all things considered, but it is going to be sold just the same, as I am going to prove to you.

Now, the Government's proposition in the matter of nitrogen, as I will try to show you, is just as ridiculous as to make clothing without trousers, because studies which they presented showing the relationship of supply and demand contemplate that ammonia nitrogen may invade the field of nitrate nitrogen. So the important question is, What is the demand for sulphate of ammonia, and what is the supply of sulphate of ammonia?

Nitrogen compounds are divisible into two great classes, inorganic and organic. The Government—and I have done the same thing and I think it is perfectly sound—has dealt with this thing from the standpoint of inorganic nitrogen, of which there are three classes. Each has its own phase. There are nitrate compounds. It is a misnomer calling all these plants nitrate plants, but it is an easy word to use. That is good enough for us for the moment. Chemically, nitrate compounds contain nitrogen linked with oxygen in the proportion of 1 nitrogen to 3 oxygen atoms. Ammonium compounds contain nitrogen linked with hydrogen in the proportion of 1 nitrogen to 3 hydrogen atoms. Cyanamid contains 2 nitrogen atoms linked to 1 carbon atom. These groupings determine the principal uses to which the compounds can be put. Each group acts entirely differently from the other groups.

Now, of the Chilean nitrates that come to this country and are used, about 45 per cent is used in agriculture and 55 per cent in the arts.

The demand for nitrate nitrogen may be classified as follows:

TABLE 7.—*Consumption of nitrate compounds in United States, 1914.*

Product demanded.	Use.	Equivalent tons nitrate of soda.	Per cent of total.
Nitrate of soda	By fertilizer manufacturers	150,000	28
Do	By farmers, fertilizer bought unmixed	90,000	17
Nitric oxide	Sulphuric-acid manufacturers	40,000	7
Do	Fortifying used mixed acid, miscellaneous chemical use.	95,000	17
Mixed acid	Nitration, dyes and explosives	65,000	12
Oxidizing agent	Glass manufacture	30,000	6
Do	Explosives, as nitrate of soda	45,000	8
C. P. chemicals, miscellaneous	Chemical industry, numerous nitrates for miscellaneous chemical uses.	25,000	5
		540,000	100

Reference: Federal Trade Commission report on Fertilizer Industry, pages 30, 102, United States Census of Manufactures, 1914.

Senator Kendrick. Right there, Mr. Washburn, I want to ask a question. Do you have any information as to the available supply of nitrates in the Chilean territories from which they have heretofore been imported?

Mr. Washburn. Yes; I have a knowledge from having engaged in the development of those fields some years ago, and knowing them by personal contact. There has been a great misunderstanding about the so-called limited supply of Chilean nitrates. There is supply so great that at the moment it would be difficult to develop any curve or anything that would show their exhaustion, and the difficulties in the industry have not been so much from the lack of supply as they have been from the increasing cost of labor and the exhaustion of very rich deposits, but experience and skill and ingenuity in the treatment of caliche, as it is called, the raw ore, has enabled the material to keep in the market with a profit by treating successively poorer and leaner ores all the time. A great deal of attention has been given in the last few years to the question of the minimum cost of Chilean nitrates. I see there is pretty good agreement between the latest investigations here and those just completed in England and they show about $40 a ton minimum cost delivered—it costs a little more to deliver it in this country than it does in England, but that is good enough, in a round figure, for both this country and Europe.

The Chairman. How does cyanamid for use as a fertilizer compare with other nitrate compounds, Mr. Washburn?

Mr. Washburn. Cyanamid as a plant food, after it is once presented to the plant and is in the soil has substantially as good crop-raising value as any other form of nitrogen per pound of nitrogen in the form of cyanamid. But cyanamid has very striking limitations in the preparation of fertilizer and in the application of the fertilizer to the soil. We can only place a limited quantity of cyanamid in a ton of mixed fertilizers, because placed in larger or greater amount than these minimum quantities it has a deleterious effect upon some of the other materials with which it is mixed, namely, acid phosphate. It is perfectly fine up to a certain point; not only has some fine fertilizing qualities, but it is the best conditioner there is for making the fertilizer mealy and easily distributed, and so forth. But the important thing for this Government to look at to-day is this question of the demand for sulphate of ammonia as compared with its supply; that is the crux of the situation. The first point of my thesis is that sulphate of ammonia can not replace nitrate of soda, but that the only effect of the increase of sulphate of ammonia will be to increase the use of Chilean nitrate. That is what I am engaged in now, making that proof.

As far back as records are available the fertilizer industry has derived a part of its nitrogen from nitrate of soda. In addition to the nitrate used in mixed fertilizers there is sold directly to the farmers, in unmixed form, about 60 per cent of the amount of nitrate used by fertilizer manufacturers. A study of fertilizer inspection bulletins shows that about 85 per cent of all nitrogen fertilizers contain nitrate nitrogen from nitrate of soda. Substantially all of them. Now, here is the reason:

Nitrate nitrogen is the only form of nitrogen that can be readily assimilated as plant food without preliminary modification in the soil. All other forms of nitrogen (except in rice growing) must be converted to nitrates before they can be utilized by the plant. The point of the moment is that when you put Chilean nitrate into the soil it at once goes to work, but when you put another form of nitrogen into the soil there must be relatively slow bacterial action before it can be utilized by the plant. In the spring of the year, when the ground is cold and nitrifying bacteria inactive, crops frequently lag in their growth on account of readily available nitrogen. In order to supply this nitrogen practically all mixed fertilizers contain a small quantity of nitrate of soda. The top dressing of crops with nitrate of soda has the same purpose, namely, to supply readily available nitrogen ahead of the time when other forms of nitrogen become nitrified.

This early feeding of the crop gives it an early start that is of great value, since the total amount of growth made by a crop in its normal life period depends upon the rate of growth from the start. This fact is particularly recognized by truck growers, potato growers, and cotton farmers. No other form of nitrogen can take the place of this use of nitrate nitrogen.

In the manufacture of chamber sulphuric acid nitrate of soda is used at the rate of about 1 per cent of the weight of sulphuric acid produced to furnish nitric oxide in the chambers. The consumption of nitrate of soda for this purpose in 1914 was about 6 per cent of the imports, or about 40,000 tons. The consumption in the present productive capacity of sulphuric-acid plants would be about twice this amount if all the plants were operating, or 80,000 tons of nitrate per annum.

Nitric oxide may be furnished by oxidation of ammonia gas. Since, however, a large sulphuric-acid plant of 50,000 tons capacity would use only 500 tons of nitrate of soda per annum it would undoubtedly be much more convenient to use nitrate than to oxidize ammonia, since the latter operation would require either dependable transportation of ammonia as needed or large storage capacity, and in addition would require a trained chemist for operation. Under the present practice nitrate for sulphuric-acid plants is taken out of the required stocks for other purposes, such as fertilizer, since more than one-half of the sulphuric acid is made by fertilizer manufacturers.

Up to the present time the price of ammonia of quality suitable for oxidation has not been substantially less than the price of the equivalent nitrate of soda. To convert nitrate of soda into nitric oxide in the sulphuric-acid chambers requires only pouring of sulphuric acid onto the nitrate contained in a suitable receptacle. The storing of nitrate of soda requires only an ordinary building with a roof. Nitrate of soda can be obtained at almost any time and can be kept indefinitely without deterioration.

The convenience and low cost of obtaining nitric oxide from nitrate of soda will undoubtedly prevent the adoption of ammonia oxidation for the same purpose.

In 1914 the production of nitric acid amounted to 90,000 tons of 100 per cent nitric acid, equivalent to about 160,000 tons of nitrate of soda. Of the nitric acid produced, about 55,000 tons was in the form of mixed acid (one part nitric to two parts sulphuric acid) and 45,000 tons as straight nitric acid.

Nitric acid is used principally for fortifying spent mixed acid used in the manufacture of industrial explosives and dyes and for miscellaneous chemical purposes. In 1914 nitric acid equivalent to about 20,000 tons of nitrate of soda was used in making ammonium nitrate for industrial explosives, but practically all of this nitric acid was from spent mixed acids for which there was no other use.

There has been a great deal of talk about the dye industry. I see much in the newspapers that the dye industry will be helped by the production of sulphate of ammonia. Well, the dye industry does not use a great deal of ammonia; it uses nitric acid principally.

The dye industry has increased from a production of about 6,000 tons of coal-tar dyes in 1914 to a production of about 35,000 tons in 1918. At the present time the production may be as much as 40,000 tons. If this estimate is correct, it is almost double the quantity of dyes reported in 1914, and this is about 50 per cent in excess of domestic consumption.

No statistics are available of consumption of nitric acid in dyes, but it is believed that the amount would not exceed the equivalent of 1 ton of nitrate of soda per ton of dye products. It would seem unlikely that the production of American dyes for export will increase in the face of German competition, since the dye industry claims that it requires tariff protection in order to hold its market in this country. This field for nitric-acid consumption, therefore, would not seem to offer any substantial possibilities of increase.

Nitrate of soda is the cheapest oxidizing agent for use in glass manufacture, in explosives, and a variety of other manufacturing operations. In glass manufacture it is doubtful whether any other form of oxidizing agent would be as suitable, since what is desired is oxygen combined with a soda base. In this case ammoniacal nitrogen is wholly useless.

The consumption of nitrate of soda as an oxidizing agent in explosives and in glass manufacture was, in 1914, 75,000 tons of nitrate of soda, or about 14 per cent of the total consumption.

Now, it is seen from the above that each of the uses to which nitrate of soda is being applied is a special use, which can be met only with nitrate of soda as such, or nitric acid, or oxides. The ammonium form of nitrogen can not perform any of these functions, although ammonium nitrogen might be oxidized to nitric oxide or nitric acid or other nitrates. Nitric oxide, being in the form of gas, would of course have to be produced at the point of consumption, and this would practically mean shipping ammonia from its point of production to the place of consumption and used as nitric oxide. It is true we have an oxidization plant for the transformation of ammonia to nitric acid right at Muscle Shoals, but that can only be used for the production of nitric acid at Muscle Shoals. We could not produce concentrated nitric acid except by an enormous outlay for additional installation, and then after we got it we could not transport it. And so, while it is true that nitric acid can be made at Muscle Shoals by the use of one of our patented processes, it is impossible to get it off the property for use anywhere else.

Senator **Wadsworth**. On account of its explosive character?

Mr. **Washburn**. No; there is the element of cost. Transportation of ammonia in tank cars is practical where the distances are not too great and where provision can be made for storage to eliminate too much dependability upon regular transportation.

Nitric acid as such, can be transported only in glass carboys, the expense of which of course precludes shipping this form of acid for large industrial uses. It must therefore be produced at the point of consumption. It would be possible to produce a mixed acid of high strength, say 90 per cent nitric and 10 per cent fuming sulphuric acid, which could be shipped in tank cars. The cost of transportation and losses would be prohibitive.

Nitric acid used in the form of mixed acids could of course be produced at a central point and be shipped to point of consumption. Since, however, the average mixed acid contains two parts of sulphuric acid to one part of nitric acid, the transportation cost would be about three times the cost of transporting the amount of nitric acid used, and in addition the cost of transporting the sulphuric acid to the nitric acid plant.

In all of the cases where it is proposed to use oxidized ammonia in place of nitrate of soda it would have to be shown in the cost of the developing nitrate compound from ammonia, including interest on investment, could be depended upon to be less than cost of such nitrates from nitrate of soda, unless nitrate of soda is excluded from the United States by means of a prohibitive tariff. It is to be presumed that the nitrate producers of Chile will make every endeavor to reduce their costs of production, and possibly reduce their export tax so as to deliver nitrate in the American market at a price low enough to insure its use in the fields where nitrates, as such, are specifically demanded.

The Federal Trade Commission, in its report on the fertilizer industry, gives several estimates of the cost of producing nitrate of soda in 1913 and 1914, the highest of which is $1.67 per hundred pounds of nitrate f. o. b. vessel, including export tax of $0.56. The cost carried to Europe was estimated equivalent to $2.02 per 100 pounds of nitrate. While costs have since increased considerably, the same is also true of the costs of producing ammonium nitrogen.

The **Chairman**. I was going to say, Mr. Washburn, I have read about the way they manufacture nitric acid in Norway, where they have cheap water power. Now, they do make nitric acid into solids and then barrel it up and ship it out. I was wondering why that could not be done here.

Mr. **Washburn**. Nitric acid in the Norwegian methods, the arc process, is the first product. That is their raw product. With cyanamid it is your last product. That is, after you have once made nitrogen by the cyanamid process you have a long way to go before you get nitric acid. And while with the Norwegian process you come in at the nitric acid end. Their cheapest process is the nitric acid end and our most expensive method is the nitric acid end. Now, there is an enormous Norwegian plant, as you know. The representative of the banking interests which own that plant has been in to see me quite lately, within the last two months; he was sent over here for the purpose of consulting on what practical use that plant might have. Out of this war they amortized the plant, the full cost of the plant, which was enormous.

The **Chairman**. You speak of the Rjükan Falls plant?

Mr. **Washburn**. Yes.

The **Chairman**. That is operated with the Eyde process?

Mr. **Washburn**. Yes; the Berklem-Eyde process. Notwithstanding that plant is paid for, that their water power does not cost them anything, after it is once there you have got to use it, and the interest account has to run against it as much when it is idle as when it is working. They have not been able to develop any peace time use for it. That is their problem to-day.

Senator **Kendrick**. Can they ship that product?

Mr. **Washburn**. It is not profitable to do so in competition with nitrate of soda.

Senator **Kendrick**. Did I understand you to say that this Chilean product, the nitrate of soda, that it is found impossible to produce that at any of your great plants that you have mentioned; that particular commodity is not produced?

Mr. **Washburn**. No; that particular commodity is not produced at any of the cyanamid plants or anywhere with cyanamid, except that during the war that is the way by which Germany, after being shut off from Chile, got her nitrate nitrogen.

Senator **Kendrick**. Then she did produce it?

Mr. **Washburn**. She did produce it, and produced it, of course, at great cost.

Senator **Kendrick**. Does this country or any other country have the German process; have the information?

Mr. **Washburn**. Well, the American Cyanamid Co. has a process which is essentially the same as the German, I think the references show.

The **Chairman**. Do you have reference now to the Haber process?

Mr. **Washburn**. No; I have reference now to the process which converts ammonia into nitric acid.

The **Chairman**. It is admitted that the Haber process is really the cheapest process?

Mr. **Washburn**. No process can be spoken of as cheapest, in general terms.

The **Chairman**. Well, we will say the most practical?

Mr. **Washburn**. No.

The **Chairman**. In other words, Germany manufactured more nitrogen through the Haber process than any other process that she was permitted to use during the war, according to statements furnished the committee.

Mr. WASHBURN. It is very clear, isn't it, that in a situation where the skill of the operator, the labor rate, and the kinds of materials and certain by-products are available for the Haber process that are desirable for the Haber process, and all of them cheap, that there would be a good place for the Haber process?

The CHAIRMAN. Yes.

Mr. WASHBURN. In the same way, where all the elements are favorable for the cyanamid process, that is the place for the cyanamid process.

The CHAIRMAN. Yes.

Mr. WASHBURN. Broadly speaking, the cyanamid process is the one that is practical at the present time—much better than the Haber process.

The CHAIRMAN. One of the reasons is that the power cost is too high?

Mr. WASHBURN. No; we have that difficulty, but notwithstanding that, the cyanamid process is superior to the Haber process. We have that handicap, of course, in the cyanamid process, but notwithstanding the high cost of power, the cyanamid process here is superior to the Haber process.

The CHAIRMAN. Let me ask you this question: Suppose we had as cheap power as they have in the Scandinavian countries, would it not be entirely practicable to use the arc process and make nitric acid into solids and then convert it into fertilizers; wouldn't that really be the ideal way to make fertilizers?

Mr. WASHBURN. No; it would not. The product manufactured by the arc process, the fertilizer product, is not practicable to use. It is hygroscopic. It is not very highly concentrated and the efforts to dispose of it, for instance, in this country have always failed.

The CHAIRMAN. Yes; I realize that. It requires more power, I understand, than any other process, and isn't that really the reason why it is not practicable in this country?

Mr. WASHBURN. No; but in Norway, where the power is very cheap, and where, under the old freights, an infinitesimal amount from Norway here, it could not be used here; it can be made in Norway and shipped here cheaper than it can be produced here, even if we had the power as cheap as Norway; that was the condition; and even then it can not find its way into this country.

The CHAIRMAN. Is that on account of the transportation charges into this country?

Mr. WASHBURN. No; it is on account of the physical limitations that the material itself has. It is pretty generally recognized, I think, everywhere that the arc process will never have any further development. There may be one or two cases where it can be used, but it will be a single plant somewhere, and no general use.

The CHAIRMAN. Am I correct in assuming that the product which they make is a proper product to be used for fertilizer?

Mr. WASHBURN. The product, after it is gotten to the plant, is an excellent fertilizer. It is another nitrate and like Chilean nitrate. It is all right when it is once put into the soil.

Now, the point that we must catch in this matter is that we are bound to use Chilean nitrate or nitrate nitrogen and we do not know of any other practical source of getting it except from Chile. The ammonia compounds, like sulphate of ammonia, can not invade that field; therefore, there isn't any possibility of operating the Muscle Shoals plant and furnishing nitrogen that otherwise would come from Chile. It is going to come from Chile just the same, whether they operate the Muscle Shoals plant or not, and if the Muscle Shoals plant is put in operation they will use more nitrate of soda.

The CHAIRMAN. In other words, we must have the product from Chile or a similar product in connection with the product which we might manufacture in order to make fertilizer?

Mr. WASHBURN. That is the point exactly.

Now, we will turn to the ammonium compounds. We are done for the moment with the Chilean nitrate compounds. There is some confusion generally in talking about sulphate of ammonia, for the reason that these quantities are not sulphate of ammonia, except in part. Ammonia is marketed in various forms, but in order to deal with the different products on a common basis of understanding, all this product is measured in equivalent of sulphate of ammonia, as it is called. That is, every 500 pounds of ammonia is called a ton of sulphate of ammonia, whether it is actually as sulphate of ammonia or not. When we talk of sulphate of ammonia, we will take one year which is typical, 1914, 150,000 tons in that year.

Now, the demand for sulphate of ammonia for fertilizer purposes has grown; we find that 55 per cent of the ammonia in the United States was used in fertilizer. And while I will turn over to the stenographer here certain information contained here, I am going to show you on charts which I have brought what this demand has grown to be; what its law of increase is. But I want to show first that all of the sulphate of ammonia used as fertilizer, with the exception of five or six thousand tons is used in mixed fertilizers. It can not be used for crops except for rice——

The CHAIRMAN (interposing). Is sulphate of ammonia represented in your samples, Mr. Washburn?

Mr. WASHBURN. Yes, sir.

The CHAIRMAN. That is the one you spoke about a while ago which is 9 per cent of the ingredients of the fertilizer?

Mr. WASHBURN. Yes. The duration of the effect of sulphate of ammonia as a fertilizer is figured as being about two months. I will not go into a discussion of that. I merely want to be as impressive as I can be in the well-recognized fact that sulphate of ammonia has its place, and Chilean nitrate has its place, and you can not cross the line.

The CHAIRMAN. Mr. Washburn, if you have any data there prepared the committee will be glad to have it inserted in the record, if you do not care to go into it in detail, because we want to get all the information possible about it.

Mr. WASHBURN. The course of my discussion from this point on is first of all to get through with this somewhat tedious but extraordinarily important matter of the demand and supply of sulphate of ammonia; to show by these curves not what the Government has shown, but entirely different conclusions—not to show that there is a scarcity, but a tremendous overplus of capacity. That is the important factor in this situation. It is the thing that deters us from finding a way to use that plant. It has driven us out of the sulphate of ammonia market already.

Now, following that, I want to show that even if the Government did produce this sulphate of ammonia, and produce all that the farmer uses and then produced it at the price they say they are going to sell it to the farmer for, and the farmer got the benefit of that price, the farmer would save only 1 cent out of a dollar on his fertilizer, if everything were done as they say.

The **Chairman**. Because of so many other ingredients entering in?

Mr. **Washburn**. Exactly; because the saving to the farmers east of the Mississippi River is only 40 cents per farm. Even if the Government did all the remarkable things they say, it does not mean anything.

Senator **Kendrick**. Do we understand from that that it is your judgment or opinion that this quality of fertilizer might be eliminated without any harmful results; you spoke of saving but 1 cent; is that the idea that you could get along without that entirely?

Mr. **Washburn**. No; the point is that there will be produced, whether there is a demand for it or not, so much more sulphate of ammonia than we can find places for, that the farmer is going to have unlimited quantities of it, and even his unlimited quantity, taking all that he will use, will only be 10 per cent of his total amount of fertilizer.

The **Chairman**. It only requires 10 per cent of this particular product, and there is still 90 per cent of other ingredients to be used?

Mr. **Washburn**. Yes, sir.

The **Chairman**. And that is why I understand, Mr. Washburn, the saving will be very small?

Mr. **Washburn**. Yes, sir.

(And thereupon, at 12 o'clock m., the committee stood in recess until 10 o'clock to-morrow.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

FRIDAY, APRIL 9, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

The committee met pursuant to adjournment at 10 o'clock a. m., in room 326, Senate Office Building, Senator Asle J. Gronna presiding.

Present: Senators Gronna (chairman), Kenyon, Keyes, Ransdell, Kendrick, and Harrison.

The **Chairman**. Mr. Washburn, you may proceed with your statement.

STATEMENT OF MR. FRANK S. WASHBURN—Resumed.

Mr. **Washburn**. Mr. Chairman, I am appreciative of the problem that faces the members of this committee as well as anyone connected with the Government in reference to plants that have cost millions of dollars erected for war use and with the great expense in the matter of interest charges and maintenance of those plants during the years of peace. It is a very natural concern and I am keenly appreciative of the naturalness and propriety of it in every way, and we should endeavor to make some good economic use of just as many of those plants as possible.

While the remarks that I made yesterday and those that I shall continue with for a time seem to be wholly destructive, I am in my intentions intensely constructive on this situation. As you see, I have no faith whatsoever in the administration plan for making use of the Muscle Shoals plant.

Senator **Kenyon**. Mr. Washburn, I did not have an opportunity to hear you yesterday, because I was in another committee meeting and have to leave in a few minutes for another one. I want to ask ask you a question, if you please. When this Muscle Shoals matter was first up in Congress, you will perhaps remember that I fought it. I do not know that you do.

Mr. **Washburn**. I do.

Senator **Kenyon**. Now, as I remember it, at that time you were before the Agriculture Committee and you earnestly urged this proposition.

Mr. **Washburn**. Not this proposition; no, sir.

Senator **Kenyon**. I thought it was this proposition.

Mr. **Washburn**. No.

Senator **Kenyon**. Of course, I thought the whole Muscle Shoals proposition was a piece of tremendous political pork, and I have always thought so. I would like to have your views.

Mr. **Washburn**. Senator Kenyon, the Muscle Shoals proposition, on the basis I stood for five years ago, I think, was a clean-cut, highly conceived national undertaking; but the Muscle Shoals proposition as it stands to-day has none of the wholesome reasons for its support that it had during the time that I stood for it. One of the things I want to make myself clear on now before I get through with this committee is this: I want to divorce myself absolutely from the present proposition to spend these millions of dollars down there—$25,000,000—on a water-power plant when you have got a steam plant already constructed, which is capable of taking care of your power requirements and doing it just as cheaply as your water power will do it.

Senator KENYON. Is not the water-power plant built?

Mr. WASHBURN. No, sir.

Senator KENYON. Well, the Government has spent about $80,000,000 down there, has it not?

Mr. WASHBURN. The Government has spent a few thousand dollars, possibly, on the water-power plant in preparing the foundations for the dam.

Senator KENYON. But on the whole scheme they have spent about $80,000,000?

Mr. WASHBURN. On the whole scheme, so far as the nitrate plants down there are concerned, they have spent about $13,000,000, on what is called plant No. 1. And they have spent about $67,000,000 on plant No. 2, which is what is known as the Muscle Shoals nitrate plant.

Senator KENYON. And what does it all amount to? Anything?

Mr. WASHBURN. It amounts to having one plant of an experimental nature which, up to this moment, is a dead loss, that never has made anything and has not yet developed a process that can make anything.

Senator KENYON. Is that the $13,000,000 one?

Mr. WASHBURN. That is the $13,000,000 plant.

Senator KENYON. That is a loss?

Mr. WASHBURN. I would not say so; I merely say that up to the present time that $13,000,000 has accomplished nothing.

Senator KENYON. What has the other accomplished?

Mr. WASHBURN. The other has accomplished the completion of a plant for the manufacture of a military explosive, ammonium nitrate, that in its operation manufactured a material superior to the specifications that were provided by our Government or any other for that material, that produced as cheaply or cheaper than was anticipated and up to full designed capacity; it is a 100 per cent performance in every respect. The Muscle Shoals nitrate plant is a complete plant that has its own steam-power plant to-day and no water power, and there is not a dollar of expenditure that I have referred to or that you have referred to that has gone into water power. That expenditure is still to be made.

The CHAIRMAN. If I am not mistaken, the money expended at Muscle Shoals has been expended in the purchase of quite a lot of land, but very little has been spent for the construction of dams?

Mr. WASHBURN. I believe that is true. You are simply referring now exclusively to the hydroelectric development?

The CHAIRMAN. Yes.

Mr. WASHBURN. The expenditures for the lands for the nitrate plants were small.

Senator KENYON. I just wanted to ask those general questions to get an idea of what was going on.

Mr. **Washburn**. There is just one small correction I want to make in the record of what I said yesterday, namely, the quotations of sulphate and cyanamid. The relative figures just at the moment are about $3.80 a unit of ammonia for sulphate in bags and $3.50 to $4 a unit of ammonia for cyanamid in bags. They are at the present time substantially the same. That is not usual; the cyanamid is usually materially lower than the sulphate figure.

For the benefit of those who were not here yesterday I might say that what we were engaged in at the time of adjournment yesterday was the development of what we believe to be the fact that there is no place in the market for the material which the administration plant proposes to make at Muscle Shoals. Instead of there being a dearth of capacity for the production of the material, there is very much over capacity, which is one of the striking and remarkable things that has resulted from the war, as everybody in the industry knows; that is, plant capacity to produce ammonia nitrogen. There is no call for any such plant or operation as this because of a dearth of sulphate of ammonia.

After all, what it is proposed to do there does not touch the fertilizer situation in any material way; because it is dealing with a material that constitutes only 10 per cent of the value of all the materials that go into fertilizer, and by the time all the benefits claimed by the administration in the matters of cost of production and selling are realized, even if the estimates of the administration are correct, and assuming it were possible to pass them over to the farmer, it would save the farmer only 1 cent on his present expenditure of each dollar for fertilizer. He might, if you would carry the whole benefit to him, get his fertilizer for 99 cents where he now has to pay a dollar. That is the subject we were engaged on last night.

The use of sulphate of ammonia in this country is about 55 per cent in agriculture and about 45 per cent in the arts—refrigeration, manufacture of soda ash and explosives, and various chemical uses, and some of the late so-called ammonia powders.

The **Chairman**. You are speaking now of times of peace?

Mr. **Washburn**. Yes; normal conditions.

Table 2.—*Consumption of ammonium compounds in United States, 1914.*

Form.	Use.	Equivalent tons sulphate of ammonia.	Per cent of total.
Sulphate of ammonia	By fertilizer manufacturers in mixed fertilizer	150,000	55
Anhydrous ammonia	Refrigeration	33,000	12
Aqua ammonia	Refrigeration, soda ash, explosives, and miscellaneous ammonium salts for chemical uses.	87,000	33
Total		270,000	100

Substantially all of the sulphate of ammonia used as fertilizer—there is an exception of 5,000 or 6,000 tons—is used in mixed fertilizers. Sulphate of ammonia can not be utilized for crops until its nitrogen has been converted into nitrate form by bacterial action. It therefore can not take the place of nitrate of soda.

The Government has exhibited here charts showing the sulphate of ammonia moving up into the field of nitrate and saving the farmer nitrate of soda, and releasing him from the thraldom of Chile, and all that sort of thing. It is a thing that can not be done, and that was developed yesterday by showing that the nitrate of soda has a peculiar and particular use in agriculture, and always has had, which use is not replacable by sulphate of ammonia. Simply because a material has nitrogen in it is no reason why that material can replace any or every other material with nitrogen in it.

The CHAIRMAN. I do not know that I ought to interrupt you, Mr. Washburn, but this committee had before it a gentleman from Minnesota, Col. Thorpe, who claims that what they call bog peat, of which there are millions of tons, especially in the South, is a better fertilizer than anything yet conceived or anything that has been used. Of course, I do not know anything about that; I have not had experience with it, nor do I know anything about it from a scientific standpoint. However, he claimed this, that if 1 ton of this peat is mixed with 7 tons of barnyard manure it will produce a fertilizer that will not only fertilize the land for one year but will build the soil up so that the soil will be as good and productive as any virgin soil, and that it will last for several years, and you can produce several crops from it.

I was very much interested in the statement the old gentleman made. He has made experinemts on a small scale on the sandiest land I know of in the State of Minnesota; out at Brainard, where they have a lot of the cut-over pine lands. He made such a showing that even Jim Hill, who was a very practical man, encouraged him. This old man got considerable land up there, and he made experiments, not only in fertilizing but in hastening the growth of trees by ditching, by a system of irrigation, and all that. I think you were here that night, Senator Ransdell?

Senator RANSDELL. I was. He explained that he conserved all the moisture that fell on the ground; it was all held there so the trees would get the benefit of it.

The CHAIRMAN. What was the idea you got with reference to the fertilizer that he described that night?

Senator RANSDELL. I thought it was perfectly marvelous if it would do what he claimed for it. And I understand it exists all over the United States; there is hardly a State where there is not plenty of it.

But I did not understand, Mr. Chairman, that you would have to mix 7 tons of barnyard manure with 1 ton of this peat to get very beneficial results. If so, you could not get very much benefit from the peat, because the 7 tons of barnyard manure would be a minus quantity in most places. He spoke of using peat in some composition; it was something you could easily get everywhere; I think it was a very small quantity of barnyard manure mixed with a large quantity of peat.

The CHAIRMAN. Maybe you are right.

Senator RANSDELL. You use a certain small quantity of barnyard manure, which would be available on almost any farm, and mix it with a large quantity of the peat, and that would give you the proportions to make virgin soil of the poorest soil on earth.

The CHAIRMAN. Perhaps I have got it turned around.

Senator RANSDELL. I think you have, Mr. Chairman. I must confess I do not know whether that peat exists in my part of Louisiana. If it is in the portions of the State that I am familiar with I do not know it.

The CHAIRMAN. I want to be pardoned for bringing that in, but anything that will help agriculture will, of course, help all the American people. If there are these salts or chemicals in the bogs, of which we have so many here in the United States, which are not being used, which are just going to waste, it seems to me it would be a good time for scientific men to make experiments with it. We all realize this is a matter which is of the very greatest importance. We can not get along without fertilizer, at least in certain sections of the country. We must have it, and anything that would help even in a small way would, it seems to me, be very beneficial. For that reason I brought it up.

Mr. WASHBURN. Mr. Chairman, one will always find special conditions and circumstances characteristic of a locality where a thing can be done, and well done, and profitably done, that could not be applied generally. Unquestionably there are places—we may assume there are—in which the amount of organic material in the soil is too small to constitute what is called a suitable culture medium for the bacteria—in which the introduction of organic material to the extent to which it exists in peat, we will say, would be an advantage. But, broadly speaking, the suggestion of the use of peat as a fertilizer is old, and experience following that suggestion shows that the opportunities for the useful employment of peat are limited, and so limited as not to make it a matter of great importance.

Senator KENDRICK. Mr. Washburn, how many years have you employed this system of taking nitrogen out of the air? How many years is it since you began?

Mr. WASHBURN. We delivered our first material to the customer in 1910.

Senator KENDRICK. Have you improved on the original method very materially in that time?

Mr. WASHBURN. Very materially.

Senator RANSDELL. So as to reduce the cost and increase production?

Mr. WASHBURN. Yes; both things have been done.

Just before you came in, Senator, we had just turned to the resumption of this matter of proof that sulphate of ammonia can not displace nitrate of soda, either in agriculture or in the arts, to any extent that would have any practical effect upon the demand for either of the materials; and I am particularly anxious to avoid such parts of the proof as would rob you of your interest in following the argument.

The CHAIRMAN. Very well.

Mr. WASHBURN. The use of sulphate of ammonia in the fertilizer industry in the United States is shown very well in Table 3.

TABLE 3.—*Consumption of sulphate of ammonia as fertilizer in United States.*

Year.	Tons of domestic sulphate.	Tons of imported sulphate.	Total.	Equivalent tons of nitrogen.
1907	25,000	35,000	60,000	12,000
1908	25,000	38,000	63,000	13,000
1909	38,000	43,000	81,000	17,000
1910	44,000	92,000	136,000	28,000
1911	40,000	95,000	135,000	28,000
1912	58,000	59,000	117,000	24,000
1913	84,000	65,000	149,000	31,000
1914	67,000	83,000	150,000	31,000
1917	125,000	9,000	134,000	28,000
1918	103,000	4,500	108,000	21,000

All the sulphate of ammonia used as fertilizer with the exception of 5,000 or 6,000 tons is used in mixed fertilizers. Sulphate of ammonia can not be utilized by plants (except by rice under irrigation) until its nitrogen has been converted to the nitrate form by bacterial action. It therefore can not take the place of nitrate of soda to furnish ready available nitrogen when the ground is cold and nitrifying bacteria inactive. As soon as the ground is warm, however, ammonia nitrogen is readily nitrified.

The duration of the fertilizing effect of sulphate of ammonia is commonly figured by fertilizer manufacturers to be about two months. It is therefore considered a medium-acting form of nitrogen—slower in activity than nitrate of soda, lasting approximately twice as long, but not as slow as organic nitrogen compounds, which usually last three or four months before they are completely utilized.

When sulphate of ammonia is compounded with acid phosphate, chemical changes take place, resulting in the formation of ammonium phosphate and sulphate of lime, or gypsum, or plaster of Paris. The mixture accordingly hardens, the extent depending upon the amount of sulphate of ammonia used and the amount of organic material present. Even with several hundred pounds of organic ammoniates present, 100 pounds of sulphate of ammonia in a ton of mixture will produce a degree of hardening which will make the fertilizer undesirable. For this reason sulphate of ammonia is not used by so-called dry mixers. It is used only by the large fertilizer manufacturers, who make up base goods containing several hundred pounds of sulphate of ammonia in a ton.

This base, after it has hardened, is broken up and ground fine, and is then used for making the finished mixtures, since after gypsum has once formed and been broken up it will not again harden and cause trouble. These base goods are always made up with at least several hundred pounds of organic ammoniates per ton, since otherwise the base when ground up will have a heavy compact texture that farmers are very much opposed to, as they fear difficulty in storing or distributing such fertilizers.

Usually sulphate of ammonia is about the cheapest form of high quality nitrogen that the fertilizer manufacturers can buy. The large manufacturers have for many years used all the sulphate of ammonia they possibly could and still meet the requirements of their customers in the way of mechanical condition and percentage of organic constituents. It is doubtful whether the large manufacturers could increase their consumption of sulphate of ammonia appreciably and still meet the requirements of their customers. The small manufacturers, namely, the dry-mixers, would not want sulphate of ammonia because they are not equipped to handle it.

Although the principal sellers of sulphate of ammonia in this country have carried on active propaganda work with farmers for about 10 years, at an expense in 1913 of about $15,500 and in 1914 of $21,000, direct sales of sulphate of ammonia to farmers have been brought up to only 5,000 or 6,000 tons per year, according to sellers. The farmers of this country have been taught for so many years and have had demonstrated to them the superior value of nitrate of soda as a top dresser and as a convenient ammoniate for home mixing, that those who are inclined to do home mixing or to use a single material as a top dressing will use nitrate of soda as long as obtainable at anywhere near the same price. Moreover, as stated above, sulphate of ammonia can not take the place of nitrate of soda in the early part of the season when nitrifying bacteria are relatively inactive.

In European countries considerable sulphate of ammonia is used for agricultural purposes, but it is not used in place of nitrate of soda, but, as in this country, to supplement nitrate of soda. While no comparable statistics are available on the consumption of sulphate of ammonia and nitrate of soda for agricultural purposes in the foreign countries, the following statistics from publications of the International Institute of Agriculture, Rome, show the consumption for all purposes, the principal of which is, of course, agriculture.

TABLE 4.—*Relative consumption of ammonium and nitrate nitrogen—Europe, 1913.*

	Sulphate of ammonia consumed, short tons.	Sulphate of ammonia exported, short tons.	Nitrate of soda imported, short tons.	Ratio of nitrate to sulphate consumed.
England (total)	108,000	375,000	157,000	1.5
Germany (total)	506,000	100,000	850,000	1.7
France (total)	105,000	(1)	355,000	3.4
United States (total)	262,000	(1)	626,000	2.4
United States (Agriculture)	150,000	....	240,000	1.6

[1] None.

It is significant that both England and Germany which export sulphate of ammonia, use one and one-half times as much nitrate of soda as sulphate of ammonia, while in the United States, which normally does not export sulphate of ammonia, the tonnage of nitrate of soda used is about two and one-half times the tonnage of sulphate of ammonia. For agricultural purposes only, the United States uses about 1.6 times as much nitrate of soda as sulphate of ammonia. This ratio is about the same as the ratio of nitrate to sulphate consumed for agricultural purposes in the principal European countries.

I think this proves that sulphate of ammonia which it is proposed to manufacture at Muscle Shoals can not hope to drive out Chilean Nitrate. In fact the more sulphate of ammonia which is used in agriculture the stronger the tendency will be to increase the quantity of nitrate of soda, for the reason that the purpose to be served by the increased use of sulphate of ammonia, namely, to increase crop production, will encourage the use of additional quantities of nitrate of soda, and, furthermore, there is a scientific principle in the fertilization of plants known as the law of limiting factors which expresses the fact that crop production is not necessarily dependent upon the total quantity of plant food furnished but upon the balance of the different kinds of plant food furnished, which inevitably leads to the necessity that if you increase one kind of plant food in your mixture you must increase all other kinds practically proportionately.

Senator KENDRICK. Mr. Chairman, I wonder if the witness would mind a question or two in reference to this general situation? I would like to ask this. I understood the witness to say the Government had expended about $62,000,000 in this Muscle Shoals Plant. Was not that your testimony?

Mr. WASHBURN. $62,000,000 plus an expenditure for a power plant and transmission line by the Alabama Power Co., adding something like $5,000,000 more. But that is an expenditure which was not made by the Air Nitrates Corporation, with which I am connected: that was to get additional power, or rather to have a surplus of power.

Senator KENDRICK. If I am interrupting the general line of your statement I will wait until you have finished, if you prefer, but I should like to get a clear view of this. Did you not argue yesterday that it would mean that in order for the Government to operate this plant it would be necessary to invest more money than the actual value of the plant amounts to at this time?

Mr. WASHBURN. My statement yesterday of that matter was that the Government proposes to use a portion of the plant that has cost it, with all the overhead and everything else loaded onto it, about $33,000,000—from $31,000,000 to $33,000,000. That is all of the present existing plant that they propose to use in making sulphate of ammonia.

Senator KENDRICK. And in order to do that they must expend $38,000,000?

Mr. WASHBURN. In order to do that they must—not must—but are. They are engaged in expending $38,000,000, or asking you gentlemen here to contribute an amount which, with what they are expending, will make $38,000,000.

Senator KENDRICK. That brings us to the point that I wanted to clear up. What is the alternative, Mr. Washburn, for the Government to accept in lieu of operating the plant itself? Is it to abandon the property, or to allow the property to lie idle, or to sell it?

Mr. WASHBURN. The profitable and best method that I know of, in the public interest, broadly conceived, is to preserve that plant in condition ready for use for the manufacture of explosives at any time we may be threatened with war; and when the time shall arrive when the markets are such and the demands for material are such that that plant can produce, and that will enable it to operate profitably and with economic advantage to the country as a whole, for the Government to dispose of that plant to private parties under the strongest kind of competitive bidding, so that it may be operated in the industry in the production of that material which at that time will have a place in the market and can be produced profitably.

Senator KENDRICK. Do I understand you to say that you would have the Government offer it for sale at the time we require it in an emergency, or offer it for sale now?

Mr. WASHBURN. It would be useless, I believe, to offer it for sale at the present time, because no one would buy it.

Senator KENDRICK. Do you happen to know whether the Government has had an offer on the plant?

Mr. WASHBURN. I do not know. I am in ignorance of any such thing.

Senator KENDRICK. Would you not consider it highly probable that while this plant might be operated now in the production of nitrates in a fairly remunerative way, within a few years, we will say before another war emergency arises, the whole scheme of manufacture might become obsolete, so as to render all this investment worthless?

Mr. WASHBURN. There is no reason to anticipate such an advance in the art as to render this plant worthless. The art has become standardized to too great an extent for such further rapid progress to be made. There will be improvements, and it is my belief the improvements can be made use of at that plant, which would be the natural thing, but the plant at this time can not be used profitably.

I am going to show you that the burden upon the Government in using that plant to-day would subject the Government to still greater out-of-pocket expense and investment; and furthermore, if it did use the plant and did produce at this loss to the Government you would have a still further economic loss to the country in the effect that that plant would have upon the by-product coke oven industry.

There is a very peculiar situation that has itself a very strong bearing upon the question of whether this proposed plan of operation is nationally advantageous or not. For when you have a valuable material that must be produced as a by-product of an industry, and the iron and steel industry is conducted on the basis of values derived from such material that must be produced, anything you do to tend to drive that material out of the market—and the capacity of the plants already in existence is far in excess of what the country can take—then you will force up the costs of production of your iron and steel very materially.

Senator KENDRICK. I do not want to lead you away from the general line of your statement, Mr. Washburn, but whether it is because I have not been able to attend all the hearings or whether the fact has not heretofore been brought out, I have been in doubt as to whether the Government had a real chance to sell the plant. And I have also been in doubt as to these other points.

Mr. WASHBURN. I said before you came in that I appreciated the importance of making use of that plant, if it is possible to do so. I know that is your difficulty, and it is the natural difficulty of every citizen that approaches this from the Government's standpoint. I am going to cover that situation.

If it were possible to use that plant profitably to the Government, then it ought to be used. By the word "ought" I mean, of course, that in the use of it the Government should comply with its contracts, naturally, and do justice to its citizens. And it is not my purpose to be destructive here on the proposition of using those plants, if they can be used; I am coming to the constructive part of it at the proper place. But that this plant can be used in any such way as the administration has devised is, I believe, wholly impossible, and I am trying to deduce the facts in this case in order that you may rely upon the facts for your guidance instead of upon personal opinions of men from the various Government departments on the one hand and other witnesses, myself included, on the other.

I want to get into your minds the simple fundamental facts in connection with this thing, which once in your minds you will be quite capable of reaching a wise conclusion. It has been my experience that it makes very little difference how difficult a problem is, whether it is technical or whether it is social or broadly economic, there are some fundamental simple principles that operate as a guide. Those simple principles I am trying to come to. At present we are engaged in the dryest and most uninteresting part of it, which is to show that the material the Government proposes to produce will have only a limited use and a limited market. That is one of the steps in the proof.

The CHAIRMAN. As I understand you, Mr. Washburn, if the Government should undertake to manufacture sulphate of ammonia—I believe that is what you are discussing now—it would affect the question of fertilizer to only a small extent—that is, 10 per cent of the total cost of that article. That is one question.

Then again, from the by-products produced in the manufacture of coke in the production of steel and iron, I take it from your statement we are getting now sufficient quantities of some of the products which we are discussing. And, of course, if the Government should undertake to manufacture some product which is only a small portion of the material used in the manufacture of fertilizer there will be competition only in that small portion so used, which would be of no value to the country. It would be of very little value to the farmer, because 90 per cent of the material used would have to be secured somewhere else anyway. If I understand you correctly, that is really your main objection, that the private business of the country can now supply a certain amount of this 10 per cent product, and at the same time that helps to reduce the price of steel and iron?

Mr. WASHBURN. Yes. The country can supply all the sulphate of ammonia that is required.

But that is not the whole story, nor could I with very much logic claim, if that were all there was to it, and the Government could operate the plant and make money and could properly operate it in accordance with its agreements and all other things that are proper and right, that it should not save what it can upon these plants that were built for war purposes. But I mentioned, as sometimes an attorney does, when he has a case, in order that those who are to hear may realize what it is he is engaged in talking about, a number of things in this situation which I think are fatal to the accomplishment of any good, from any point of view, in the employment of that plant. And one of the facts that are fatal to the accomplishment of what the Government, or those speaking for the Government, have claimed, namely, benefit to the farmer, is based on this very fact, that, after all, the farmer would only get from this plant some material the total quantity of which is represented by less than 10 per cent of his fertilizer.

Right in that connection, to give point to it, the farmers are of the impression that the Muscle Shoals plant is a fertilizer plant. You know, it is always spoken of as that. They say there is a shortage of fertilizer, and they come to you gentlemen, and they use their influence and quite properly, and say, "Please start up the Muscle Shoals plant and aid agriculture." A perfectly sound argument, if the facts were there to support it. So far as the farmer knows, the facts are there.

But the shortage of fertilizer is not in sulphate of ammonia, not by any means. My company is a producer of phosphate rock—among the largest in the country. Our output during a part of last year was 60 per cent, and at other times 75 per cent, of the output of the country of phosphate rock. The reason we are having a shortage of fertilizer to-day—and we know it to our own cost, for we are losing money on it every day—has been the strikes and the railroad situation. Where we can use 50 or 60 cars a day we are getting 10, and that is all the railroads can furnish us. In our district there is one locomotive handling our enormous business, and we can not get another locomotive.

And the phosphate rock is going to the fertilizer manufacturers, to produce what? Anything to do with that 10 per cent? No, gentlemen; to produce that amount of material [indicating the phosphate in the glass tubes previously exhibited and explained]. That is what the farmer is not getting. And yet some cunning gentleman says to the farmer that the Muscle Shoals plant is a fertilizer plant. The Muscle Shoals plant is not going to produce that [indicating phosphate and potash]; it is going to produce that kind of material [indicating sulphate of ammonia]. And here is your total fertilizer. That is the kind of thing that happens in Washington over and over and over.

The Chairman. I am very glad that you have so fully answered the question which I really intended to ask. I had reference, of course, absolutely to peace times. I realize that in times of war, even if we could manufacture only a small proportion, it is not a question of cost at all. I want that understood, because I am not speaking about war times at all, and I am not speaking about the manufacture of explosives for any other purpose than simply commercial use.

Senator Kendrick [indicating glass tubes]. Mr. Washburn, do these different products represent the quantities of all fertilizers used, and are they used in the proportion shown in these vases?

Mr. Washburn. The quantities are indicated by the written figures here; the space occupied by each is proportional to its value.

Senator Kendrick. Not to the quantities used?

Mr. Washburn. Not to the quantities, but to their value.

Senator Ransdell. Is that ammonium sulphate made from atmospheric nitrogen?

Mr. Washburn. No; it is a by product of the coke ovens. It can be made from atmospheric nitrogen.

Senator Ransdell. But is not atmospheric nitrogen used in making the fertilizer?

Mr. Washburn. Yes; but not that fertilizer.

Senator Ransdell. That is what I thought; but you can make atmospheric nitrogen at this Muscle Shoals plant, can you not?

Mr. Washburn. Yes.

Senator Ransdell. Then it would be possible to make the fertilizer at the Muscle Shoals plant——

Mr. Washburn (interposing). Which is not sulphate of ammonia.

Senator Ransdell. Yes.

Mr. Washburn. That is right. Let us see what that would add. That would add that little ring there [indicating cyanamid in glass tube].

Senator Ransdell. What do you call that little ring?

Mr. WASHBURN. That is cyanamid; it would add that much—that is, provided the Government could make it under its contract with the American Cyanamid Co. The Muscle Shoals plant is operated only under a contract with the American Cyanamid Co.

Senator RANSDELL. What are the terms of that contract? I do not mean all the terms, but how long will it last? Is not that something that the Government could annul if it thought it would be advantageous?

Mr. WASHBURN. No.

Senator RANSDELL. Does it last indefinitely?

Mr. WASHBURN. It does not last indefinitely; it lasts until 1932. But the comfortable way of looking at that would be for us to assume that the American Cyanamid Co. would give the Government that right and, if you choose, let us assume it would give the Government that right for nothing. It does not amount to anything in the fertilizer situation.

Senator RANSDELL. If the Government had it, you claim it would not amount to anything?

Mr. WASHBURN. No; and when I have talked about the 10 per cent here I have really included the cyanamid, because the sulphate of ammonia amounts to only 9 per cent.

Senator RANSDELL. And that is the only other product which could be gotten out of the plant there which would be beneficial to agriculture?

Mr. WASHBURN. That is correct.

Senator RANSDELL. Then there is a very great misapprehension in the minds of the public about it.

Mr. WASHBURN. An interesting fact here, when you speak of the possibility of sulphate of ammonia displacing the Chilean nitrate, is that England, which has been the great exporter of sulphate, still brings in from Chile one and a half as much nitrate as she uses of sulphate.

Senator KENDRICK. As I understood your contention yesterday, it was in effect that the more of the sulphate they used the more of the nitrates they would be compelled to import from Chile? Was not that your statement?

Mr. WASHBURN. That is entirely correct; and I think it would be of interest to you to know why that is so, in a more specific way than I stated yesterday.

To return to my argument on the consumption of fertilizer materials I will next discuss the use of organic ammoniates. The question is a proper one as to whether sulphate of ammonia may not displace organic ammoniates in agriculture by reason of a larger percentage of the organic nitrogenous materials going into cattle food. There is nothing new as to this state of affairs. It has been going on for some years and, therefore, when we project the future demand for inorganic nitrogenous materials upon the past and present demand, we are taking account of every tendency in the uses of organic materials. It is for this reason that the Government has confined its studies as to the future demand for inorganic nitrogenous materials upon the history of these materials in the past and at the present time, and it is for this reason that I am doing the same thing.

I might say, however, that there is no ground whatsoever for anticipating a tremendous slump in the use of organic materials in agriculture for the reason that already half of the organic materials are used for other purposes than agriculture, and the other half is composed chiefly of materials which can not go into feeding stuffs by their very nature, and of the remaining materials, such as cottonseed meal and tankage, there would always be a considerable amount of such quality as to make them unfit for feeding purposes. In addition to this as to cottonseed meal, the farmer will always carry home from the gin, as he has in the past, a large quantity of crushed seed which he gets in barter and which has to bear no transportation expense or be subjected to the take out of various traders and middle men.

In the field of fertilizers organic nirtogen compounds enter into competition to a certain extent with inorganic nitrogen compounds. Since a large part of the production of organic materials is also used as stock foods, it is sometimes assumed that all or at least a large part of the organic materials used as fertilizer migh be diverted into stock foods, thus making room for additional utilization of sulphate of ammonia. The importance of organic ammoniates and the distribution of use as between fertilizers and feeds is shown in the following table of average consumption for 1912 to 1917 (three peace years and three war years):

TABLE 5.—*Average consumption of organic compounds (1912–1917.)*

Product.	Tons of product.				Tons of nitrogen.			
	Used as fertilizer.	Used as feed.	Per cent of total.		Used as fertilizer.	Used as feed.	Per cent of total.	
			Fertilizer.	Feed.			Fertilizer.	Feed.
Cottonseed meal as direct fertilizer	500,000	840,000	23	39	29,000	55,000	21	40
In fertilizer industry	300,000	....	14	......	18,000	....	....	......
Exported	....	520,000	....	24	....	34,000	13	25
Tankage	240,000	80,000	75	25	18,700	7,000	73	27
Dried blood	27,000	6,000	75	17	3,000	700	75	17
Fish	50,000	....	100	......	3,300	....	100	......
Miscellaneous organics	600,000	....	100	......	30,000	....	100	......
Base goods, garbage, etc.	1,717,000	926,000	54	29	102,000	62,700	51	32
Exported	....	520,000	....	17	....	34,000	....	17

References: Federal Trade Commission Report on Fertilizer Industry; Fertilizer Control Survey of Fertilizer Industry; American fertilizer handbooks; United States Census of Manufacturers, 1914.

It is seen from the above table that about 37 per cent of the cottonseed meal produced from 1912 to 1917 was used as fertilizer, 39 per cent as feed, and 24 per cent exported. These proportions vary somewhat from year to year with the size of the cotton crop (cotton seed crushed) and the supply of competitive feeding stuffs. As a general rule, a large cotton crop produces a large outturn of meal, with consequent reduced prices. This encourages increased use of meal as a fertilizer on the following crop in place of other fertilizers. A shortage of competitive feedings stuffs, together with a normal cotton crop, on the other hand, will run the price of meal up and make mixed fertilizers made with little or no meal relatively cheaper, thus discouraging the use of meal. The European demand for meal also has some influence on domestic prices. As far as can be determined from the statistics, however, there is no ground for the "discovery" made every few years by casual writers on this subject that the use of cottonseed meal in feeds is increasing rapidly, and therefore that its use as a fertilizer must be decreasing.

It is true that the use of meal as feed is increasing, but so is its use as fertilizer, both due to the increasing production. The Federal Trade Commission says in its Report on the Fertilizer Industry, pages 57, 59:

> More than 50 per cent of the cottonseed meal produced in North Carolina, South Carolina, Georgia, and Alabama is consumed for fertilizer purposes. In the States west of the Mississippi River a much smaller per cent is used in this way, as the bulk of the total output is exported, and most of the remainder is sold for stock feed. The Bureau of Soils, of the Department of Agriculture, estimated that of the entire production of cottonseed cake and meal about 33 per cent is used for fertilizer and 67 per cent for stock feed.
>
> Although the use of cottonseed meal as a food for stock has been gradually increasing, it is probable that the actual tonnage used as a fertilizer material has not materially decreased, due to the fact that the proportion of the cotton seed produced reaching the oil mills is constantly increasing, it being estimated that more than 80 per cent of the 1914 crop reached the oil mills, while in 1907 probably only a little more than 50 per cent was utilized.

The following table shows the increase in production of cottonseed meal and cake in the United States:

TABLE 6.—*Production of cottonseed meal and cake in the United States, 1890–1916.*

Crop year.	Cotton produced.	Cottonseed produced.	Cottonseed crushed.	Per cent crushed.	Cottonseed meal and cake produced.
	Bales.	*Tons.*			*Tons.*
1890	8,750,000	4,093,000	1,023,000	25	358,000
1900	10,102,000	4,830,000	2,315,000	50	845,000
1910	11,568,000	5,175,000	4,106,000	79	1,792,000
1916	11,363,000	5,113,000	4,479,000	88	2,225,000

Reference: Department of Commerce, Bulletin 153.

No records of consumption of cottonseed meal as fertilizer and as feed have been kept from year to year. The Federal Trade Commission in its Report on the Fertilizer Industry, 1916, gives a table of estimated consumption as fertilizer and as feed from 1902 to 1914, but this is based on the estimate of the Department of Agriculture that about 33 per cent of the meal produced is used as fertilizer and 67 per cent as feed.

The United States census gives the consumption of cottonseed meal in the manufacture of fertilizers, and the Fertilizer Control of the Department of Agriculture obtained, by means of a questionnaire, statistics for 1917 and 1918. These figures are given in Table 7 following:

TABLE 7.—*Cottonseed meal used by fertilizer manufacturers.*

Year.	Fertilizer manufactured.	Cottonseed meal used.	Ratio of cottonseed meal to fertilizer.	Year.	Fertilizer manufactured.	Cottonseed meal used.	Ratio of cottonseed meal to fertilizer.
		Tons.	*Per cent.*			*Tons.*	*Per cent.*
1899	2,937,205	9,[illegible]00	0.3	1914	8,414,959	325,234	3.9
1904	3,645,847	116,300	3.2	1917	6,591,638	306,399	4.6
1909	5,614,718	(1)	(1)	1918	7,080,684	273,876	3.9

(1) Not available.

References: United States Census of Manufactures; Fertilizer Control Survey of Fertilizer Industry, 1919.

Table 7 fails to indicate any decrease in the percentage of meal used in mixed fertilizers.

The Fertilizer Control Survey of the Ferilizer Industry gives a table showing the disposal of meal produced in the 16 principal producing States. A summary of these statistics is given in Table 8. They show that 35 per cent of the meal produced was used for fertilizer purposes in 1918, in comparison with 33 per cent estimated by the Department of Agriculture in 1913 and previous years.

TABLE 8.—*Disposal of cottonseed meal in 16 States, fertilizer year 1918.*

	Tons.	Total accounted for.
Used as fertilizer at point of production:		*Per cent.*
By oil mills	62,656	
By farmers	200,905	
	263,561	18.2
Shipped	243,625	16.8
Total	507,186	35.0
Used as feed:		
At point of production	186,952	12.9
Shipped	756,581	52.1
Total	943,533	65.0
Total accounted for	1,450,719	100.0
Total unaccounted for	165,898	
Grand total, 16 States	1,616,617	
Total production in United States	1,838,455	

Disposal of cottonseed meal calculated for United States, 1918:

Used as fertilizer—	Tons.
At point of production, 18.2 per cent of 1,838,455	334,000
Shipped, 16.8 per cent of 1,838,455	309,000
By fertilizer manufacturers (see reference below)	273,876
Total, 35 per cent of 1,838,455	643,000

Reference: Survey of the Fertilizer Industry; United States Fertilizer Control, Department of Agriculture, 1919.

None of the statistics or other authoritative information available indicates any diversion of cottonseed meal from fertilizer use to use as feed. While no records are available, it is very likely that the line between fertilizer use and feed use is drawn principally by the quality of the meal. Practically all the bright, high-protein meal, including 7½ per cent ammonia and up is used for feeding purposes, while practically all the dark, low-protein meal containing from 7 per cent ammonia down to less than 6 per cent ammonia is used for fertilizer purposes. When there is a relative over-production of meal in any year (the fluctuations from year to year average about 370,000 tons), a certain amount of bright meal may be used as fertilizer, but the great bulk for fertilizer use is dark meal, unsuited for feeding purposes.

It is a common belief that cottonseed meal is an expensive form of nitrogen to use for fertilizer purposes. It is true that the quoted prices divided by the percentage of ammonia contained, figure out on an average about 30 per cent higher than the quoted unit prices of inorganic ammoniates. The cottonseed meal price, however, includes the value of 1½ to 2 per cent phosphoric acid and 1½ to 2 per cent of potash. Deducting this value, leaves a unit price for the ammonia about 15 per cent above the average wholesale quoted prices of inorganic ammoniates. Cottonseed meal, however, is quoted f. o. b. mills, that is, there is little freight for the farmer to pay. The retail price on small lots is only about 5 per cent higher than the wholesale price. Nitrate of soda, on the other hand, is quoted f. o. b. ports, in lots containing about five times as much nitrogen as a minimum wholesale lot of cottonseed meal. The average farmer in buying nitrate therefore actually pays the quoted wholesale price plus freight to the interior point plus retailer's carrying charge, commissions and profit, all of which together make the price of nitrate to the farmer actually higher than the price of meal.

Then, too, meal is a home product sold by the local oil mill. It is a very common practice for farmers to exchange seed for meal. Naturally, the oil mill operator, although he may handle other fertilizer materials, prefers to encourage the use of his own product as far as consistent with his profits.

It is practically a universal belief among fertilizer consumers and manufacturers that a fertilizer whose nitrogen is principally organic gives better crop results than a fertilizer whose nitrogen is mainly inorganic. A study of fertilizer inspection bulletins indicates that over 98 per cent of all ammoniated mixed fertilizers contain organic nitrogen.

The following table shows the relative amounts of organic compared with inorganic nitrogen consumed in mixed fertilizers, average 1912–1917.

TABLE 9.—*Nitrogen consumption in mixed fertilizers.*

	Tons of product.	Tons of nitrogen.	Per cent of total nitrogen.
Cottonseed meal	300,000	18,000	14
Other organics	917,000	55,000	43
Total organic	1,217,000	73,000	57
Nitrate of soda	140,000	22,000	17
Sulphate of ammonia	135,000	28,000	22
Cyanamid	25,000	4,600	4
	300,000	54,600	43
Total in mixed fertilizers	1,517,000	127,600	100

Reference: Federal Trade Commission Report on Fertilizer Industry; Fertilizer Control Survey of Fertilizer Industry; American Fertilizer Handbook; United States Census of Manufactures, 1914.

As a component of mixed fertilizers it is seen that cottonseed meal furnishes only 14 per cent of the total nitrogen, which is a great deal less than is commonly supposed. In other words, if it is proposed to make room for more ammonia nitrogen in mixed fertilizers by omitting cottonseed meal, the vacancy created by withdrawing all the meal would not be as large as is commonly assumed. Part of this meal is consumed in mixed fertilizers by the oil mills, while most of the balance is in response to demands for special formulas.

The favor in which organic ammoniates are held seems to be extremely deep-rooted. The explanation usually given by farmers and fertilizer manufacturers for their preference for organics is that they believe that a mixture of quick-acting, medium-acting, and slow-acting ammoniates will feed the crop uniformly throughout its period of growth and give a better result than an application of quick or medium acting ammoniates alone. Further, they are afraid that inorganic ammoniates will cause "burning." Many farmers have no explanation other than that their experience has shown that the organics have produced superior results per dollar of investment.

It is possible that the common method af applying fertilizers in the row along with the seed may explain the superiority of organics as they are used. It is known that contact of the seed with inorganic ammoniates may easily injure the delicate roots to such an extent that a great part of the potential value of the fertilizer is annulled. Fertilizer manufacturers and experiment stations have for years advocated application in such ways as will prevent contact between seed and fertilizer, but with little effect. The farmer wants to get the fertilizer near the seed, where he believes it will do the most good.

Another reason for the favor in which organics are held lies in the effect they have on mechanical condition. While it is possible to prepare a mixed fertilizer which after curing and regrinding will remain in fair mechanical condition even if made entirely from inorganic materials, it is much less expensive to get dependable condition with organic materials. Farmers are accustomed to a certain texture and bulk in mixed goods and insist on having it.

The consumption of tankage for use as fertilizer was estimated by the Federal Trade Commission to be equal in 1914 to 210,000 tons of high-grade tankage containing 18,000 tons of nitrogen. The consumption in stock foods was estimated to be equal to 34,000 tons of tankage containing 3,000 tons of nitrogen.

The fertilizer control found the consumption for fertilizer purposes in 1917, 294,266 tons of tankage containing 23,000 tons of nitrogen; and in 1918, 216,655 tons of tankage containing 18,000 tons of nitrogen. The consumption in stock foods is given for 1918: 83,400 tons containing 7,300 tons of nitrogen.

The comparison in terms of nitrogen, therefore, is as follows:

TABLE 10.

Year.	As fertilizer (tons of nitrogen).	As feed (tons of nitrogen).
1914	18,000	3,000
1917	23,000	....
1918	18,000	7,300

The figures given cover too short a period and are too variable to give any dependable ideas on the trend. While more than twice as muck tankage was used as feed in 1918 as in 1914, the amount used as a fertilizer seems to have been unaffected.

Of the total nitrogen used as fertilizer, tankage furnishes about 11 per cent (see Table XV).

Dried blood production was estimated by the Federal Trade Commission to be equal in 1914 to 40,870 tons containing 5,500 tons nitrogen. The distribution between fertilizer and stock and poultry foods was not estimated.

The fertilizer control reports the consumption in fertilizers in 1917 as 37,189 tons containing 4,200 tons of nitrogen, and in 1918, 25,799 tons containing 2,900 tons of nitrogen.

In 1918 they found sales for use as fertilizer 26,918 tons containing 3,060 tons of nitrogen and for feed 5,671 tons containing 640 tons of nitrogen.

The comparison is:

The figures are too variable to be significant. The total consumption of blood in fertilizers furnishes about 2 per cent of the total nitrogen used.

Dried fish and acid fish are used practically entirely for fertilizer purposes. Since 1913 the production has averaged about 23,000 tons of dried scrap per annum, containing about 1,700 tons of nitrogen, and about 21,000 tons of acid scrap containing about 1,000 tons of nitrogen. The nitrogen furnished by fish is about 1½ per cent of the total nitrogen used for fertilizer purposes.

Statistics of this important class of organic nitrogen compounds are unfortunately obtainable for only a few years, and these show large variations. From the Census of Manufactures, 1914, and from the fertilizer control's report the following calculations have been made, covering all organics except cottonseed meal, tankage, blood, and fish.

TABLE 11.—*Tons of nitrogen.*

1914	Total.	As fertilizer.	As feed.
1914	5,500		
1917		4,200	
1918	3,700	3,060	640

TABLE 12.

	Tons, miscellaneous organics.	Tons nitrogen.
1914	760,000	40,000
1917	813,716	25,500
1918	785,000	24,300

The principal materials in this class are as follows:

TABLE 13.—*Consumption of miscellaneous organic ammoniates, average 1917–18.*

	Tons product.	Tons nitrogen.
Garbage tankage	110,000	3,100
Guano	50,000	3,900
Castor pomace	28,000	1,600
Leather scrap	16,000	1,700
Hair and wool waste	10,000	1,300
Hoof meal	6,000	400
Base goods and miscellaneous	555,000	12,300
Total	785,000	24,300

Base goods is made by adding sulphuric acid to ground phosphate rock mixed with crude materials such as fur, felt, leather, hair, feathers, peanut hulls, grape pomace, peat, garbage tankage, and other waste products containing organic nitrogen. Before the war there was imported considerable quantities of artificial tankages made by acid treatment of leather scraps and other industrial wastes. Imports of organic ammoniates other than guano in 1914 contained about 12,000 tons of nitrogen.

The future supply of these miscellaneous organic ammoniates can not be estimated from the meager statistics at hand. Since, however, the utilization of waste materials by fertilizer manufacturers is almost as old as the fertilizer industry, it may be assumed that about the only further expansion in this line will be such as accompanies the increase of population and industry.

The following table summarizes the consumption of nitrogen compounds for fertilizer purposes. The average for three peace years, 1912 to 1914, and three war years, 1915 to 1917, is taken on the assumption that it represents the present conditions better than either the prewar statistics or those of the war period alone.

TABLE 14.—*Nitrogen consumption as fertilizer, average 1912–1917.*

Product.	Tons of product.	Tons of nitrogen.	Per cent of total nitrogen.
Inorganic:			
Nitrate of soda	225,000	35,000	21.4
Sulphate of ammonia	135,000	28,000	17.1
Cyanamid	25,000	4,600	2.8
Total	385,000	67,600	41.3
Organic:			
Cottonseed meal—			
Outside fertilizer industry	500,000	29,000	17.8
Inside fertilizer industry	300,000	18,000	11.0
Tankage	240,000	18,700	11.5
Dried blood	27,000	3,000	1.8
Fish	44,000	2,700	1.7
Garbage tankage	110,000	3,100	1.9
Guano	60,000	3,900	2.4
Castor pomace	28,000	1,600	1.0
Leather scrap	16,000	1,700	1.0
Hair and wool waste	10,000	1,300	.8
Hoof meal	6,000	400	.3
Base goods, miscellaneous	555,000	12,300	7.5
Total	1,896,000	95,700	58.7
Grand total	2,281,000	163,300	100.0

The trend of fertilizer consumption in the United States is shown by the following statistics of tonnage of all fertilizers and fertilizer materials sold by fertilizer manufacturers. This does not include cottonseed meal or nitrate of soda handled outside of the fertilizer industry.

TABLE 15.—*Tonnage of fertilizers sold by fertilizer industry in the United States, 1880–1918.*

Year.	Tons.	Year.	Tons.
1880	1,150,000	1909	4,912,000
1890	1,950,000	1910	5,760,000
1900	2,200,000	1911	6,355,000
1901	2,500,000	1912	6,112,000
1902	2,770,000	1913	6,712,000
1903	3,075,000	1914	7,518,000
1904	3,360,000	1915	5,783,000
1905	3,850,000	1916	5,583,000
1906	4,450,000	1917	6,423,000
1907	4,451,000	1918	6,992,000
1908	4,525,000		

Reference: American Fertilizer Handbook, 1915, 1919.

Plotting the results of Table 15 gives, from 1900 forward, a straight-line curve. In other words, the increase is not geometrical—that is, a percentage increase—but is an arithmetical or additive increase, averaging about 350,000 tons per annum. The indicated tonnage consumption for 1925 is 10,900,000 tons and for 1930 is 12,650,000 tons, assuming that the war has no effect on the industry. As a matter of fact, shortage of phosphate rock, shortage of potash, and poor transportation conditions have produced a considerable decrease in tonnage even below the 1914 figures. The 1920 tonnage of fertilizers, it is estimated, will be only about 5,000,000 tons compared with 9,150,000 tons indicated on the curve, a deficiency of 4,150,000 tons or 45 per cent.

From the above survey the following conclusions seem evident:

1. The present by-product ammonia capacity and the estimated near-by future capacity exceeds the domestic demand for ammonium compounds.

2. Ammonium compounds can not be used in place of nitrate compounds for industrial purposes without conversion to the nitrate form. Such conversion is practicable only where the market value of ammonia is much below the price that the nitrate of soda producers will take rather than go out of business.

3. Ammonium compounds can not be substituted for organic nitrogen compounds in fertilizers, either factory-mixed or home-mixed, without first destroying or greatly diminishing an almost universal preference on the part of fertilizer consumers for organic forms of nitrogen.

4. Increase of consumption of nitrogen compounds for both agricultural and chemical purposes is normally an additive or arithmetical function, not a percentage or geometrical function.

5. World production of ammonium compounds has almost doubled since the outbreak of the war, while the production of nitrate compounds has remained even, and the world demand for either or both forms is less than prewar production. Operation of existing capacity for ammonium compounds would give a vast overproduction with prices declining to levels that would put out of business those plants not economically situated to continue operation at almost any price level.

We meet in this thing, gentlemen, the same difficulty that men meet in every art. I have no doubt a man could go before inexperienced men in the East with a bit of gold ore in his hand, and lock the door and be secretive and say, "Gentlemen, there is a bit of gold ore; I have got a mine out West"; and everybody would be tremendously interested, and I am not sure that some of these Eastern people would not want to invest.

Senator **Kendrick**. It has been done.

Mr. **Washburn**. It has been done. That is what we call in chemistry the qualitative analysis. It is true there is some gold in it, but if it is only a dollar a ton and it is a refractory ore, the fact is not significant. You can not do anything but lose money if you operate that gold mine.

But here in this complicated fertilizer situation men are always coming in with a piece of gold ore, and all they know about it is that it has got a little gold in it. This situation lends itself to a quantitative analysis, just like the quantitative analysis of a piece of ore, as to the quantity of valuable metal in it and the cost of extracting that valuable metal. That is what I am trying to give you—the quantitative analysis.

The CHAIRMAN. That may be applied not only to the man who wants to sell the gold ore but to agriculture as well. I do not say it is possible, nor do I think any one who has studied agriculture will dare to say it is impossible, that with proper scientific skill it is possible to put organic matters into the soil so that it will not be necessary to use any of these products at all. I know that people who have devoted a lifetime to the study of agriculture believe it is possible by the proper rotation of crops, by the seeding of clovers, alfalfas, and all such crops which attract the atmospheric substances and through their roots deposit them in the ground, we can do away with all these compounds. I do not say that this is possible, nor would I want to say that it is impossible.

But the trouble with agriculture is—and I want to be pardoned for bringing this observation into this scientific discussion—that anybody can go on the farm and farm. The fact of the matter is, and I have said this on the floor of the Senate, that it requires more brains, more science, and more common sense to be a good farmer than it does to be a lawyer or a legislator.

But in our discussion here I can not help but think of the necessity of being the right sort of farmer. Instead of robbing your soil of the absolutely necessary qualities to produce a crop, a farmer ought to be able to improve his farm every year, just like you improve your scientific processes. That is what the farmer would do if he were the right kind of farmer. But every time we undertake to do anything which really goes to the farm there is always a complaint that it is too expensive and we do not get results. When that condition changes I think perhaps we can solve this whole problem so far as agriculture is concerned without as much difficulty as is anticipated.

Senator RANSDELL. Along the line of what you have just said, Mr. Chairman, is it not a fact that the people of Europe, and more particularly the Germans prior to the outbreak of the late war, had made marvelous advances in agriculture by scientific methods of farming and proper fertilization; so much so that they were producing on the lands of Germany, which have been cultivated for probably for two or three thousand years, fully twice as much wheat per acre as we were producing on our comparatively new lands that had been cultivated only a very few years? That was due, I take it, solely to their scientific methods of fertilizing and cultivating their soil, both with the plants that produce nitrogen, as you have described, and with fertilizers of various kinds. I am not familiar with that system, but it certainly was scientific farming.

The CHAIRMAN. I understand that to be so.

Mr. WASHBURN. To return to the statistics of production in 1914, the last year unaffected by the war so far as the United States is concerned, there was a production of ammonia nitrogen in the United States expressed in equivalent sulphate of ammonia of 183,000 tons, and there was imported 89,200 tons of actual sulphate. The total consumption, therefore, was equivalent to 272,000 tons of sulphate (I might say that only 150,000 tons of this went into fertilizers).

The production in this country in 1919, despite the steel strike, was 435,000 tons, the whole of it in by-product ammonia from the by-product coke ovens.

In five years the actual domestic production increased two and a half times, and incidentally I might say that the imports fell off to nothing. However, this does not express the full disproportion in capacity to produce for the reason that the number of by-product coke ovens completed on January 1, 1920, amounted to 10,379, with 853 under construction; together a total of 11,232 ovens. These at the present rate of production of ammonia represent 505,440 tons of sulphate of ammonia, and if to this we add the production from gas works of 55,000 tons we have a total of 560,440 tons as the productive capacity of the ovens completed and those under construction. We are therefore confronted with the startling fact that with a normal demand in this country in 1914 of 272,200 tons equivalent sulphate of ammonia we have to-day a productive capacity of 560,440 tons. Even if we should assume that the agricultural demand has grown each year of the war in the same ratio as it proceeded prior to the war and superimposed this upon the consumption in 1914, we should have increased the quantity used only by about 150,000 tons, or to, say, 425,000 tons. There is nothing in history or in the agricultural or industrial situation in the United States which indicates that this assumption does not give a greatly exaggerated figure over the actual domestic demand for 1920. The world situation is even more extraordinary. The total ammonia production of the world in 1913 was equivalent to 1,770,000 tons of sulphate of ammonia. The producing capacity in 1919 is estimated at 4,625,000 tons equivalent sulphate, or 2.61 times as much.

This, in connection with other facts which will be developed later, settles beyond peradventure the possibility of the United States engaging in the export of sulphate of ammonia, and even if it did undertake it, the Government would not want to establish a factory and operate it for the purpose of exporting the product.

These facts also, I believe, demonstrate that we can reasonably expect to receive importations of sulphate from abroad. The broad fact which I wish to call to your attention as a guide to judgment is, therefore, that over a period of five to six years the country has increased its productive capacity in comparison to the demand at the beginning of the period of about three times, and during this period of five to six years there has been a very declining use in agriculture of that material, being, in 1914, 150,000 tons; 1917, 134,000 tons; 1918, 108,000 tons. These facts alone do not constitute a complete analysis or all of the factors that have to bear upon the relation of future supply and demand. These factors, however, have been brought together and analyzed, together with the facts just mentioned to you in the preparation of the curves which are shown upon the charts exhibited on the walls of this room.

As a basis for the construction of such a chart Table 16, covering the demand for a supply of inorganic nitrogen in the United States for the period 1900 to 1919 is here presented.

TABLE 16.—*Consumption of inorganic nitrogen in the United States, 1900–1919.*

Year.	Nitrate of soda.		Sulphate of ammonia.			Tons of nitrogen.	Cyanamid (fiscal year).	Total.
	Imported (tons).	Tons of nitrogen.	Produced.	Imported.	Total.			
1900	....	....	27,600	8,400	36,000	7,400	....	....
1901	192,000	30,000	29,300	14,400	43,700	9,000	....	39,000
1902	205,000	32,000	36,100	18,200	54,300	11,200	....	43,200
1903	273,000	42,600	41,900	16,700	58,600	12,100	....	54,700
1904	228,000	35,600	54,600	16,700	71,300	14,700	....	50,300
1905	321,000	50,100	65,300	15,300	80,600	16,600	....	66,700
1906	372,000	58,000	75,000	9,200	84,200	17,300	....	75,300
1907	365,000	57,000	99,300	30,600	129,900	26,750	....	83,750
1908	311,000	48,500	83,400	34,300	117,700	24,250	....	72,750
1909	428,000	66,900	106,500	40,200	146,700	32,000	....	98,900
1910	529,000	82,500	116,000	62,200	178,200	36,700	550	119,800
1911	545,000	85,000	127,000	103,400	230,400	47,500	1,480	134,000
1912	485,000	75,900	165,000	81,100	246,100	50,700	2,000	128,600
1913	626,000	97,700	195,000	67,000	262,000	54,000	2,300	154,000
1914	542,000	84,500	183,000	89,200	272,200	56,100	5,300	145,900
1915	772,000	120,400	249,400	65,400	314,800	64,900	4,500	189,800
1916	1,218,000	190,000	288,300	22,700	311,000	64,100	8,200	262,300
1917	1,543,000	240.900	370,000	9,900	379,900	78,300	9,400	328,600
1918	1,845,000	288,000	450,000	5,200	455,200	93,900	9,500	391,400
1919	315,000	49,200	[1] 435,000	....	435,000	89,600	12,000	[2] 150,800

[1] Exported.

[2] Shipped Jan. 1 to Dec. 31. Does not include nitrate of soda stored in United States.

References: American fertilizer handbooks; Department of Commerce statistics.

The general trend of an industry is somewhat difficult to see from such a statistical presentation. I have, therefore, prepared in pictorial or graphic form a chart showing the above figures for consumption, based upon the above Table 16, to which I wish to call your attention. (Plate 2.) On the base line is indicated the years to which the statistics apply. For each year as indicated I have plotted in terms of tons of nitrogen the scale which is shown at the left of the chart, the consumption of the various classes of nitrogen compounds. Beginning in 1901 the first year for which statistics are given in Table 16, I will call your attention to the point B. Running from B toward the right is a broken line, more or less uniformly increasing its distance from the base line and ending at the point L in 1918. The vertical distance between this line and the base line for any given year as shown, represents the tons of nitrogen consumed in the form of nitrate of soda for that year. You will notice that up until the outbreak of the war in 1914 this line shows a more or less uniform increase of importations, but in 1914, the outbreak of the great war, the importations showed a very decided increase, as indicated by the more sharply upward trend of the line to the point L in 1918 at the close of the war.

In 1910 the first cyanamid was brought into this country, and I now call your attention to the line just above that, representing nitrate of soda and beginning with 1910 and ending at the point K in 1918. The importation of cyanamid nitrogen is small compared to that of nitrate of soda, but it shows an increase in the fact that the distance from L to K is somewhat greater than at the start in 1910.

Starting in 1901 we will now add on in a vertical direction to the nitrogen obtained from nitrate of soda, that obtained from the coke ovens and gas works in the form of sulphate of ammonia. Repeating this for each year up until 1910, and after that continuing our addition in the same vertical direction to that of the cyanamid import curve, we obtain a new line some distance above the nitrate of soda and the cyanamid curve which represents by its distance from the nitrate of soda and the cyanamid curve, the production of nitrogen from the by-product coke ovens and gas works. The result of this addition is a new curve somewhat parallel, but not exactly so, to the base line to which it was added and continually widening in distance as it approaches point H, representing the production of coke-oven ammonia.

There has been sulphate of ammonia imported into this country in greater or less quantities, and on top of this sulphate of ammonia production curve which we have just drawn I have reproduced as the top line of my diagram a curve showing the total amount of nitrogen obtained from nitrate of soda, from cyanamid, from sulphate of ammonia production and from sulphate of ammonia imports.

I will call your particular attention to the sharp upward trend of this total nitrogen consumption curve at the year 1914. You will notice that this upward trend is occasioned first by a very greatly increased importation of nitrogen in the form of nitrate of soda, but it is also affected by the fact that cyanamid nitrogen and sulphate of ammonia nitrogen also has shown a marked increase since the year 1914. On the other hand you will notice that the importation of sulphate of ammonia shows a decided reduction and in fact practically disappears in 1918

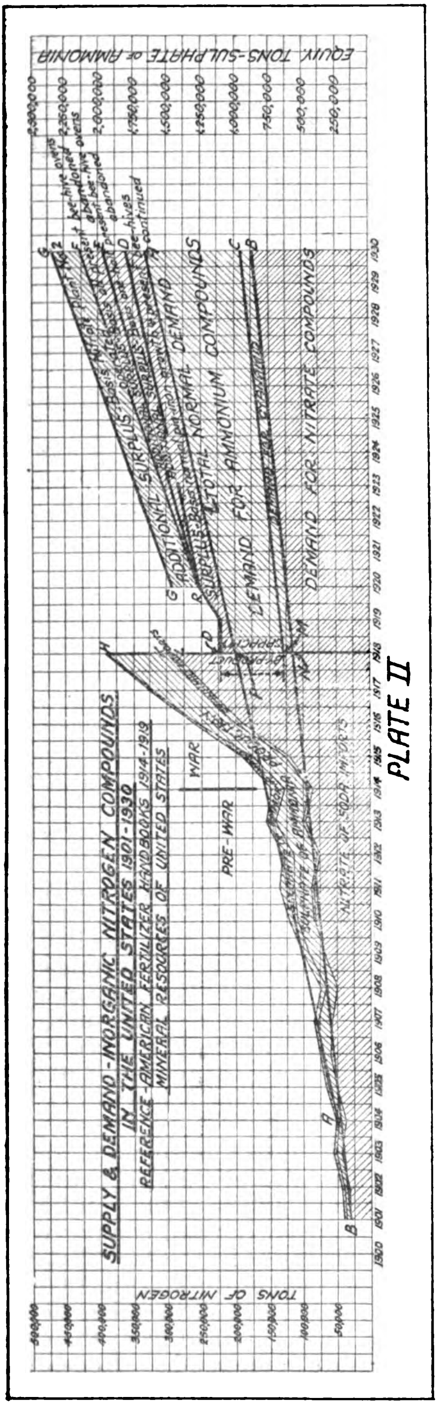


PLATE II

The nitrate of soda curve shows several minor fluctuations, but I think it is quite clear to the observer that it has a rather uniform upward trend which would indicate the average rate of increase. I have drawn in the line BNB, which represents this average rate of consumption of nitrate of soda as determined between the years 1901 and 1914 and projected to 1930.

In the case of total nitrogen consumption from the various sources represented in the curve, we have also drawn a line representing the average, beginning at the year 1904, when the coke-oven industry was fairly well started in this country, which average line is represented by the line APA.

The lines representing the average BNB and APA prior to the year 1914 are quite representative of the curve in consumption of nitrate nitrogen and of total nitrogen in the form of both nitrate and sulphate. The extraordinary demands of the war, however, called for a consumption which greatly exceeded the average rate of increase prior to the war if projected over the four years of war, as, for example, in the case of total nitrogen by the distance from H to P.

Let us now examine the actual condition at the close of the war. The consumption of nitrate of soda for 13 years prior to the beginning of the war is what is known as a straight-line average, or an arithmetical average, and there is nothing in the history of the industry which would lead us to believe that such average would not have continued for many years beyond 1914 had there been no war. Assumptions of a percentage or geometrical increase are not confirmed by the statistics 1901 to 1914. Any attempt to apply a geometrical curve to the prewar data during the early periods will not fit the actual data of consumption just prior to 1914. We are therefore forced by the laws of mathematics to project into the future by the extension of that curve which would be determined by the known developments from year to year. Any other projection is merely guessing. We therefore have no other foundation to proceed on in projecting future statistics of nitrate of soda consumption than that of the straight line already indicated, and we have so treated that line in the chart and prolonged it through the point N to the point B, as showing the only logical future projection of consumption for nitrate nitrogen. In 1925 we can anticipate that there will be 260,000 tons of nitrate nitrogen demanded by various industries, and in 1930 310,000 tons of nitrate nitrogen.

As a matter of fact, curves of production and consumption following all great wars have always shown a smaller demand than had no war occurred, but rather than interject such an assumption into our present presentation I have chosen to assume that following this war there will be no lessened demand due to the effects of the war.

Exactly the same argument applies to the projection of the demands for total nitrogen in all industries. Since for many years prior to the war this average was a straight line, and as I have just explained there is no law of mathematics which warrants changing the nature of that line into any other form of curve, my only logical procedure would be to continue this line on the basis of its past history, and by so doing I obtain the line APA.

Extending the line of total nitrogen demand to the year 1925, indicates a total nitrogen consumption demand of 275,000 tons, of which nitrate nitrogen is 150,000 tons. Cyanamid nitrogen is 15,000 tons, which leaves 110,000 tons from coke ovens. This is roughly equivalent to 550,000 tons of sulphate of ammonia.

In the year 1930 the total anticipated consumption of inorganic nitrogen from all sources is 328,000 tons, of which nitrate soda will of supply 173,000 tons, cyanamid 15,000 tons and sulphate of ammonia 140,000 tons. The 140,000 tons of nitrogen demanded from the coke ovens is equivalent to 700,000 tons of sulphate of ammonia.

Let us now return to the year 1918 at the close of the war and examine the available supply of ammonia nitrogen derived from the coke ovens. At the close of the war the producing capacity of the by-product coke ovens which recover ammonia was 95,000 tons of nitrogen, equivalent to 455,000 tons of sulphate of ammonia. There was a surplus over our anticipated demands of 20,000 tons of nitrogen equivalent to 100,000 tons of sulphate of ammonia.

In 1919 the producing capacity of the by-product coke ovens had increased by virtue of the fact that new ovens were being completed and brought into production. The steel strike, however, affected the output of by-product coke and consequently of by-product ammonia and, as a result, in 1919 there was a production of about 90,000 tons of nitrogen equivalent to 450,000 tons of sulphate and the surplus over anticipated demands was 10,000 tons of nitrogen or 50,000 tons of sulphate of ammonia. This is shown on the chart by the break in the line to the right of "D" for the year 1919.

At the close of the strikes, the coke ovens went into operation, and for the year 1920, according to authorities in the industry, we may expect from them 111,000 tons of nitrogen equivalent to 555,000 tons of sulphate of ammonia. There is a surplus for this year of between 25,000 and 30,000 tons of nitrogen from the coke ovens above the normal domestic demand for ammonia nitrogen, which surplus is equal to from 125,000 to 150,000 tons of sulphate of ammonia over and above the anticipated demand of agriculture and manufacturers. It is this surplus that forms the basis of the present export of ammonium sulphate.

So far we have figures of production based upon actual statistics and upon actual knowledge possessed by the individuals most prominent in the by-product oven industry, and from the year 1920 on we must project our future production upon the basis of such knowledge as we possess of the past.

In projecting into the future the output of by-product ovens, the following facts must be kept in mind: Referring to the publications of the United States Geological Survey we find that since 1906 the production of coke in bee-hive ovens, which do not recover ammonium sulphate as a by-product, has, while fluctuating with industrial conditions of prosperity and depression, remained practically constant. Now the total consumption of coke in the country is directly proportional to the production of pig iron. Pig iron production, while fluctuating with business conditions, has conformed since 1893 to a straight line curve of increase, with an average annual gain of about 800,000 gross tons. Since bee-hive ovens have not increased since 1906 the increased quantity of coke required to produce the increased tonnage of pig iron must, therefore, have been obtained from new by-product ovens. If, therefore, we assume that pig iron will continue to increase normally and that the increased coke required will come from new by-product ovens it is easy to calculate how much ammonia will be produced along with the coke. This calculation is shown in Table 17.

Table 17.—*Assuming existing beehive ovens remain constant in next 10 years and pig iron increases normally.*

Year.	Pig iron production.	Coke required.	Net tons coke; gross tons iron.	Net tons coke in beehive ovens.	Tons in by-product ovens.	Net tons equivalent sulphate of ammonia produced.				
						Per ton coke.	Total in by-product ovens.	Total in gas works.	Grand total.	Net tons nitrogen, total.
	Gross tons.	*Net tons.*								
1893....	7,000,000	9,400,000	1.34	9,387,150	12,850	....	....	....	....	....
1913....	30,700,000	46,100,000	1.45	33,385,000	12,715,000	0.0120	153,000	42,000	195,000	40,000
1914....	23,100,000	34,500,000	1.49	23,280,000	11,220,000	.0124	139,500	43,500	183,000	37,700
1915....	29,800,000	41,500,000	1.39	27,428,000	14,072,000	.0140	197,128	52,311	249,439	51,400
1916....	39,100,000	54,500,000	1.40	35,431,000	19,069,000	.0124	235,265	53,000	288,265	59,400
1917....	38,185,000	55,500,000	1.45	33,061,000	22,439,000	.0145	324,770	45,274	370,044	76,200
1918....	38,526,000	56,480,000	1.46	30,482,000	25,998,000	.0154	400,000	50,000	450,000	92,700
1919....	30,583,000	44,822,000	1.46	19,651,000	[1]25,171,000	....	....	....	....	....
1920....	37,500,000	54,300,000	1.45	21,700,000	32,600,000	.0154	500,000	55,000	555,000	114,000
1925....	43,250,000	62,700,000	1.45	21,700,000	[2]41,000,000	.0154	630,000	60,000	690,000	142,000
1930....	49,000,000	71,100,000	1.45	21,700,000	[2]49,400,000	.0154	760,000	65,000	825,000	170,000

[1] 1919 operation below capacity, account coal and steel strikes.

[2] Increase all from by-product ovens, 1920 and later figures estimated, except number of ovens Jan. 1, 1920

Table 18.—*Assuming all existing (1920) beehive ovens become replaced in 10 years by by-product ovens.*

Year.	Pig iron production.	Coke required.	Net tons coke; gross tons iron.	Net tons coke in beehive ovens.	Tons in by-product ovens.	Net tons equivalent sulphate of ammonia produced.				
						Per ton coke.	Total in by-product ovens.	Total in gas works.	Grand total.	Net tons nitrogen, total.
	Gross tons.	*Net tons.*								
1920....	37,500,000	54,300,000	1.45	21,700,000	32,600,000	0.0154	500,000	55,000	555,000	114,000
1925....	43,250,000	62,700,000	1.45	10,850,000	51,850,000	.0154	800,000	60,000	860,000	177,000
1930....	49,000,000	71,100,000	1.45	....	71,100,000	.0154	1,095,000	65,000	1,160,000	239,000

Table 19.—*Assuming that one-half of existing (1920) beehive ovens become replaced in 10 years by by-product ovens and pig-iron increases normally.*

Year.	Pig iron production.	Coke required.	Net tons coke; gross tons iron.	Net tons coke in beehive ovens.	Tons in by-product ovens.	Net tons equivalent sulphate of ammonia produced.				
						Per ton coke.	Total in by-product ovens.	Total in gas works.	Grand total.	Net tons nitrogen, total.
	Gross tons.	*Net tons.*								
1920....	37,500,000	54,300,000	1.45	21,700,000	32,600,000	0.0154	500,000	55,000	555,000	114,000
1925....	43,250,000	62,700,000	1.45	16,275,000	46,425,000	.0154	715,000	60,000	775,000	160,000
1930....	49,000,000	71,100,000	1.45	10,850,000	60,250,000	.0154	927,500	65,000	992,500	204,000

TABLE 20.—*Assuming all existing (1920) beehive ovens replaced in 10 years, but no pig iron increase.*

Year.	Pig iron production.	Coke required.	Net tons coke; gross tons iron.	Net tons coke in beehive ovens.	Tons in by-product ovens.	Net tons equivalent sulphate of ammonia produced.				
						Per ton coke.	Total in by-product ovens.	Total in gas works.	Grand total.	Net tons nitrogen, total.
	Gross tons.	*Net tons.*								
1920....	37,500,000	54,300,000	1.45	21,700,000	32,600,000	0.0154	500,000	55,000	550,000	114,00
1925....	37,500,000	54,300,000	1.45	10,850,000	43,450,000	.0154	570,000	60,000	630,000	130,0
1930....	37,500,000	54,300,000	1.45	....	54,300,000	.0154	837,000	65,000	902,000	185,50

In addition to the new by-product ovens projected and being built to provide coke for the increased pig-iron production, however, we must not lose sight of the fact that as beehive ovens wear out they are replaced not by beehive ovens but by by-product ovens. If we, therefore, take account of this discarding of the beehive ovens and follow the best authorities as to the rate of this replacement we would find that by 1930 it is common belief that there will be no beehive ovens in operation in this country. This would amount to the same that the ammonia now wasted in the production of 21,700,000 tons of coke made to-day (1920) in beehive ovens will be made available, by virtue of the fact that this same coke will then be produced in by-product ovens and will yield us about 67,000 tons of nitrogen per year or 335,000 tons of sulphate of ammonia. In other words, upon the basis of existing information, in 10 years from now, or in 1930, ammonium-sulphate recovery from by-product operations will amount to not only that produced to-day plus the yearly increase occasioned by an increase in pig-iron production, but in addition there will be sulphate available to the extent of 335,000 tons due to the fact that present bee-hive ovens will have been replaced by by-product ovens. In other words, in 1930 it is quite logical to look for a probable maximum production of by-product nitrogen to the extent of 232,000 tons, equivalent to 1,160,000 tons of sulphate of ammonia. (Table 18.)

There is, however, a possible contingency whereby the increased production of coke to meet the increased demand of the pig-iron industry would come wholly from by-product ovens, and, in addition, it is conceivable that not all of the beehive ovens will be replaced by by-product ovens in this 10 years; and we have, therefore, made an assumption that only one-half of the present existing beehive ovens may be abandoned by 1930. In that case, our total production of by-product nitrogen will be 198,500 tons, which is equivalent to 992,500 tons of sulphate of ammonia. (Table 19.)

Referring to plate 2, the various conditions just outlined are represented by the following lines:

The line BN represents the normal demand for nitrate nitrogen upon the assumption that future history of this demand is governed by past history between the years 1901 and 1914 as already described.

The line MC indicates the demand for cyanamid upon the assumption that this demand is not likely to increase at any greater rate than past history has indicated, the distance between the lines MB and MC for each year representing the tons of nitrogen coming from cyanamid.

The line PA represents the total anticipated demand for all nitrogen compounds based upon the past history between the years 1904 and 1914. The vertical distance for any year between the lines PA and MC represents the demand for ammonia compounds, both in fertilizer and in the manufacturing industries.

The line RD represents the total anticipated supply of ammonia compounds based upon the present by-product oven capacity and the recognized fact that increased demands of the iron industry for coke will be met with wholly from the erection of new by-product ovens. This line RD is determined by using the line MC as a base line and measuring in a vertical direction from the line MC for each year the anticipated production of nitrogen from the present coke ovens, plus the anticipated production from new coke ovens built to meet the increasing demands of the pig-iron industry.

Upon the assumption, which is agreed to by many authorities on by-product coke production, that the present beehive ovens will be abandoned in 10 years, we will obtain in 1930 a quantity of nitrogen estimated at 70,000 tons in the form of ammonia compounds obtained from additional by-product ovens built to replace the abandoned beehive ovens. This fixes the line RF.

On the assumption of half the beehive ovens being abandoned in 10 years, which is made as a measure of conservatism, the line RE has been drawn, the distance DE being half that of DF.

For any year the anticipated surplus of production over normal demand is represented by the distance between the line PA and the line RF, which distance should be measured in a vertical direction for each year at which the information is desired.

The Muscle Shoals plant has a producing capacity of 45,000 tons of nitrogen if operated to capacity. If we add this possible production from the Muscle Shoal plant to the quantities which we can reasonably expect from the by-product coke ovens, we obtain the line GG. This information is presented to show the comparative quantities of nitrogen which may be expected from the Muscle Shoal plant in comparison with the total nitrogen to be expected from the by-product coke ovens, and also in comparison with the totals anticipated in normal demand. It practically amounts to adding to the already existing surplus, as indicated in Table 21, 45,000 tons of nitrogen or 225,000 tons of sulphate of ammonia.

The CHAIRMAN. Is that all taken from the coke, Mr. Washburn?

Mr. WASHBURN. Yes; it is all taken from the coke. That is 625,000 tons. At the present time the producing capacity of this country for sulphate is 625,000 tons.

Senator KENDRICK. And what is the normal consumption?

Mr. WASHBURN. The normal consumption in agriculture in 1914 was 150,000 tons, and the consumption for all purposes in 1914 was 285,000 tons.

Senator RANSDELL. Is that sulphate produced from the coke ovens?

Mr. WASHBURN. From the coke ovens.

Senator RANSDELL. Almost entirely?

Mr. WASHBURN. Almost entirely; all but about 55,000 tons of it, which was produced in gas plants.

Senator **Ransdell**. What percentage of the coke ovens are so built that you can save that product? Are not a great many of them open, so that the product escapes, or do you get the sulphate in the open oven, the beehive oven?

Mr. **Washburn**. The amount of coke produced in by-product ovens is about half, or a little more than half, and the amount produced in the beehive oven, the wasteful oven, is a little less than half.

Senator **Ransdell**. So even the wasteful oven produces this sulphate?

Mr. **Washburn**. The wasteful oven does not produce the sulphate. and this capacity here is entirely in the by-product oven, plus a little in the gas plants.

Senator **Ransdell**. Is there not a tendency to make all of those ovens closed or by-product ovens? Is not that change going on rather rapidly?

Mr. **Washburn**. Yes; it is not only going on rapidly, but this war has introduced a thing which, if it had not been for the war, would have put back the development of the by-product coke oven for years, and that is this: The making of iron and steel before the war. which is a competitive operation, was so little influenced by the amount of by-product coke that was used that the man who did not use by-product coke could make his iron and steel and stay in the market with it; but now the proportion of coke that is produced from the by-product oven has grown so large that it leaves only a relatively small number of people without that kind of coke, and it sets the basic cost for iron and steel, and all the rest of the fellows have got to come to it.

Now, to answer your question. The steel industry reports that in 10 years it will have replaced all of the present wasteful beehive ovens with by-product ovens.

Senator **Ransdell**. I should think a large factor in the argument in favor of taking all of the by-product ovens is that those by-products, many of them, are quite valuable.

Mr. **Washburn**. Absolutely so, and the growth of our industries here makes more use of them. Not only that, but the by-product oven has been the pet example of the conservationists of the thing that all governments and all people ought to encourage.

Senator **Ransdell**. Do we not get the famous coal-tar products that we hear so much about from the by-product ovens?

Mr. **Washburn**. Quite right.

In order that you may see at a glance the surplus sulphate of ammonia as interpreted from the preceding argument, I would call your attention to Table 21, in which this surplus is indicated for each of the three conditions of beehive oven abandonment and for each of the three years 1920, 1925, and 1930. You will notice that this surplus varies from 125,000 tons under the minimum assumption up to 460,000 tons under the maximum assumption for the year 1930, but in every case it is a surplus of considerable magnitude.

TABLE 21.

Basis and item.	Tons equivalent sulphate of ammonia.		
	1920	1925	1930
Normal pig-iron production, line RD:			
Supply of by-product ammonia	555,000	690,000	825,000
Demand for ammonia compounds	425,000	550,000	700,000
Surplus	130,000	140,000	125,000
Normal pig-iron production, plus one-half beehive ovens abandoned, 1930, line RE:			
Supply of by-product ammonia	555,000	775,000	992,500
Demand for ammonium compounds	425,000	550,000	700,000
Surplus	130,000	225,000	292,500
Normal pig-iron production, plus all beehive ovens abandoned, 1930, line RF:			
Supply of by-product ammonia	555,000	860,000	1,160,000
Demand for ammonia compounds	425,000	550,000	700,000
Surplus	130,000	310,000	460,000

Now, what is that excess in there, gentlemen? It is not something that a man is going to manufacture in competition with this Government; it is something that occurs anyhow. You can not stop the making of ammonia in by-product coke ovens. It costs the steel industry just as much to throw that ammonia into the stream and not have the farmer or anybody else take it as to sell it, except that if it is prepared for sale they have to add sulphuric acid, which is expensive, besides the labor necessary to change it from ammonia gas to sulphate. But the ammonia itself, which is the thing that you want—the sulphuric acid is merely used as a vehicle for carrying it—you are bound to produce. That is not what is going to be produced if there is a market for it; that is the amount that is going to be produced if the coke ovens are used, all of them. There is your capacity to produce.

Now, you have on top of that a Government plant, in the operation of which every single dollar of your expense is an out-of-pocket expense. If the Government was going to produce that anyhow and had to throw it away, that would be a different proposition. But here you are, gentlemen; you have to put up $38,000,000 to produce a material in addition to this capacity which is already in excess of your demand.

Returning to Table 21 you will note that the surplus for any of the three assumed conditions is of decided magnitude, and particularly in the case of a considerable replacement of beehive ovens by by-product ovens this surplus becomes very large.

This surplus must be disposed of in one or more of three ways:

First. It will be exported if the world demand is greater relatively than the demand of the United States.

Second. It will be dumped on the domestic market with drastic forcing down of the price of the entire domestic ammonia compounds.

Third. If the price goes too low so as to make recovery unprofitable, the ammonia will be wasted at the source.

In order to properly comment upon the disposal as outlined above, it is necessary for us to examine into the controlling factor which undoubtedly is the state of the world market for ammonia compounds. Fixed nitrogen is an international commodity. The demand, however, does not express itself as a demand for nitrogen in general, but for specific forms of nitrogen compounds. The World War has added to the world's primary nitrogen production, particularly to ammonia compounds, and less to nitrate compounds, as shown in the following table:

TABLE 22.

	1913 production.	1919 producing capacity.	Gain.	
			Tons.	Per cent.
Nitrate of soda	432,000	452,000	20,000	5
By-product ammonia	315,000	460,000	145,000	46
Cyanamid	35,000	[1] 250,000	215,000	615
Haber ammonia	4,000	215,000	211,000	5,300
Total	354,000	925,000	571,000	161

[1] United States, 50,000; foreign, 200,000.

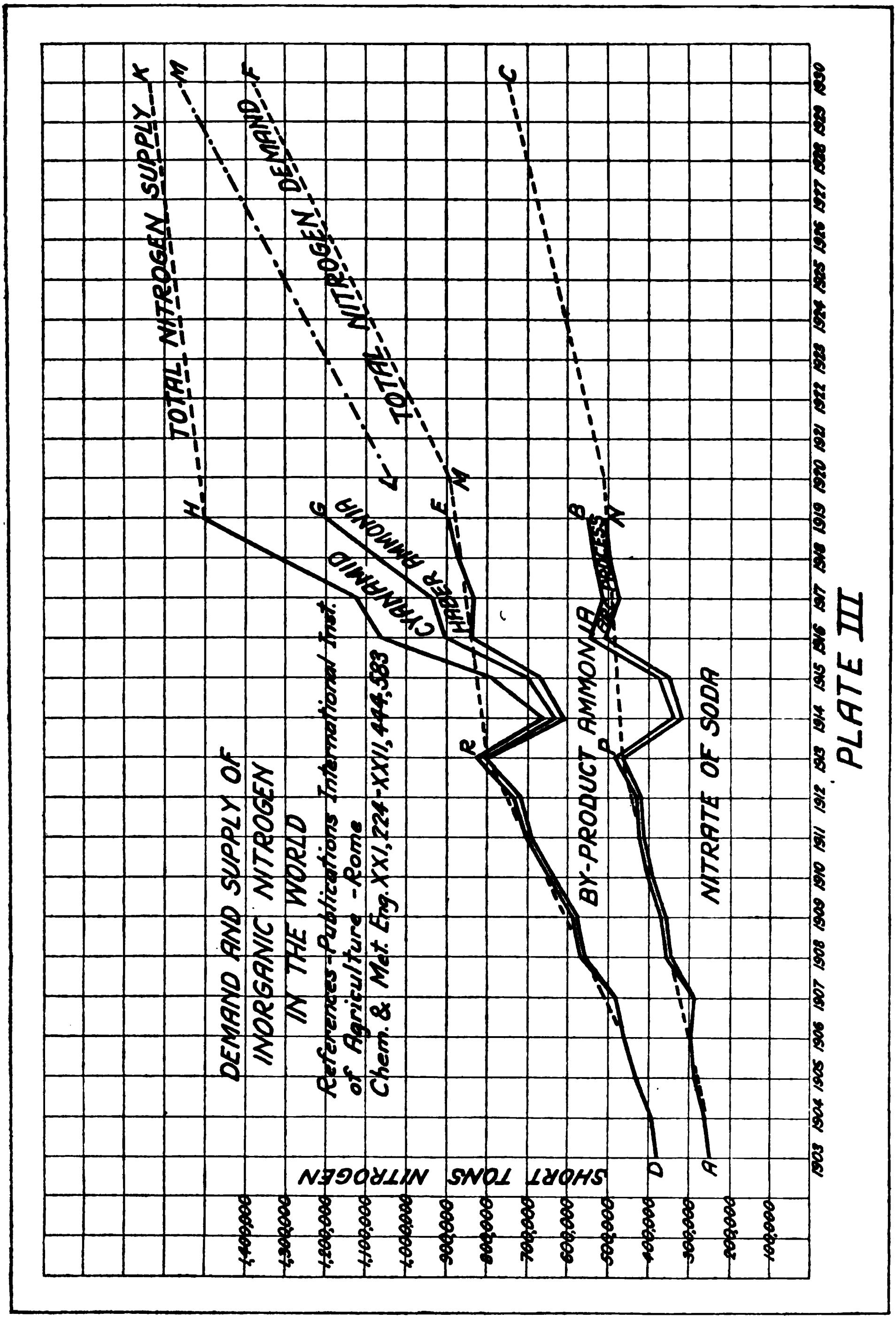
References: C. G. Gilbert, Chem. and Met. Eng., Mar. 10, 1920; R. E. McConnell, Journal Ind. and End. Chem., September, 1919.

While the productive capacity of Chilean nitrate of soda has remained at practically a standstill, the world's productive capacity of ammonia nitrogen has increased 161 per cent, or by an amount (571,000 tons) exceeding the entire production of nitrate nitrogen (452,000 tons).

The demand for ammonium compounds certainly has not increased in any such ratio as the supply. There is undoubtedly, therefore, a vast excess of capacity over demand for ammonia nitrogen. For oversupply there is only one economic remedy. The price must fall until it invites increased consumption on the one hand, and discourages production on the other hand. Those plants will operate which have the lowest costs of production. This will include practically all the by-product capacity—460,000 tons of ammonia nitrogen compared with 315,000 tons before the war. If there has been an increase in demand beyond this increase in supply, such increase will be supplied by those air-nitrogen plants which can be operated with any profit at all at the prevailing prices, while those economically more expensive to operate will simply have to shut down until demand raises the prices of the product above the cost of making it.

A forecast of the world's ammonia demand in 1925 and 1930 would be pure speculation, owing to the severe set back given to consumption in the principal European countries by the war. In fact, it would be more pertinent to ask how many years will elapse before the prewar consumption is regained abroad, than to ask when demand will get back to a curve projected on the assumption of ignoring the effects of the war.

The world situation is shown graphically in plate 3 and following a principle upon which plate 2 was constructed of using horizontal distances to represent years and vertical distances to represent quan-


DEMAND AND SUPPLY OF
INORGANIC NITROGEN
IN THE WORLD
References - Publications International Inst.
of Agriculture - Rome
Chem. & Met. Eng. XXI, 224 - XXII, 444, 583
SHORT TONS NITROGEN
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
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1930
TOTAL NITROGEN SUPPLY
TOTAL NITROGEN DEMAND
CYANAMID
AMMONIA
HABER
BY-PRODUCT AMMONIA
NITRATE OF SODA
A
D
P
R
N
B
E
G
H
L
M
F
K
C

PLATE III

tities of nitrogen. We have platted up until the year 1919 the world's consumption of nitrogen in nitrate of soda, to which we have added nitrogen received from the arc process. We have further added the nitrogen obtained from by-product coke ovens, and on top of that, and year by year, we have added the nitrogen obtained from the present existing Haber plants and present existing cyanamid plants.

You will notice that up until 1913 the world's consumption of nitrate nitrogen increased again as a straight-line function. This is a pure arithmetical and additive increase and is not a geometrical or percentage increase. The same thing is true of total nitrogen as represented by the line DR, this again being a straight line beginning in 1906 when the by-product coke-oven industry began to get on a progressive producing basis.

In 1914 there was a decided slump in the production of both nitrate nitrogen and ammonia nitrogen occasioned by the general disturbances to industry incident to the outbreak of the war in that year. Shipping became scarce, affecting nitrate nitrogen, and the closing down of industries affected coke production. The effect of the war made itself more and more strikingly felt in a decided increase in 1914 in the demands for nitrate nitrogen and particularly so in that for ammonia, so that at the close of the war, or more markedly in 1919, the last year for which statistics are available, the world had a very material increase in producing capacity for nitrogen as represented by the height to which the point H was raised. It will be particularly noted that the greater part of this increase was due to the erection of new plants for the fixation of atmospheric nitrogen either by the Haber process or by the cyanamid process. In 1919 the total producing capacity of all forms of inorganic nitrogen amounted to 1,500,000 tons of nitrogen.

To projuct the future supply and demand for nitrogen throughout the world beyond the year 1920 involves consideration of the industrial situation throughout the world. In the first place there has been little or no industrial development outside of the United States, and agriculture has been seriously hindered in most of the countries at war. We have therefore made the following assumption with regard to the probable future demand for the various forms of nitrogen. In the case of nitrate of soda we have assumed that from the year 1913 to the year 1920 the world as a whole, outside of the United States, was not in a position to use any increased quantities of nitrate of soda, but that the United States had not been handicapped so severely by the effects of the war, and it, therefore, was in a position to accept nitrate of soda to the extent of its normal increasing demand curve. Upon this assumption we have drawn the line PN, which represents a standstill with respect to foreign demands for nitrate of soda, but have included the increased United States demands, as indicated in plate 2. From the year 1920 to the year 1930 we have assumed that the world's demand for nitrate of soda will increase at the same rate as from 1903 to 1913 and have drawn a line, NC, parallel to the line AP.

We have used identically the same projection of the assumed wartime consumption of ammonia compounds in that the world as a whole, excepting the United States, was not in a position to use any more ammonia compounds in 1920 than in 1913, but that the United

States demands had grown as indicated in plate 2, and we therefore projected the line RM to indicate this assumption. From 1920 to 1930 we assumed that the world's total nitrogen demand was increased at the same rate as from 1905 to 1913 and projected the line MF from the point M, parallel to the line DR.

Our total nitrogen demand for the world in 1920 is, therefore, about 900,000 tons of nitrogen; in 1925, 1,140,000 tons of nitrogen; and in 1930, 1,380,000 tons of nitrogen, from inorganic sources.

In 1919 the world had a producing capacity of 1,500,000 tons of nitrogen, or a surplus over demands of 600,000 tons of nitrogen, practically all of which was in the form of ammonia; or, in other words, had a surplus of about 3,000,000 tons of sulphate of ammonia as producing capacity.

Such a surplus as this would naturally be a serious handicap to future developments of the industry. We have, therefore, assumed as a probable growth of the total nitrogen supply, that, excluding the United States, there will be no new fixation plants built of any considerable size in the world. In the United States, however, we have the problem of supplying coke for the normal growth of the pig-iron industry, and as this new supply will come from by-product ovens, we are certain that it is perfectly proper to add a corresponding amount of ammonia to the world's supply, and we have, therefore, determined the line HK as representing the world's future producing capacity of nitrogen based upon no material growth outside of the United States, and only a normal growth in the United States corresponding to increased pig-iron production.

The area between the lines HK and MF represents surplus nitrogen supply, which surplus varies from the equivalent of 3,000,000 tons of sulphate of ammonia in 1920 to 1,300,000 tons of sulphate of ammonia in 1930.

An interesting fact which has developed recently is that Germany proposes to exclude Chilean nitrate of soda and to produce her own nitrates. The magnitude of the German consumption of nitrate nitrogen is indicated by the vertical distances between the lines MF and LM. If this German proposal actually goes into effect it will result in lowering the line NC by the distances NL with a corresponding reduction in the ammonia area. This does not affect the world's surplus, however, inasmuch as it merely reduces the quantity of available ammonia nitrogen and throws into surplus capacity a corresponding amount of nitrate nitrogen.

In view of this enormous surplus of nitrogen in the world there is no question at all but that some of the fixation plants and some of the nitrate properties in Chile must of necessity close down, as even a demoralization of prices would not cause the utilization of any such surplus quantity as is noted by the area HKFE in plate 3.

To give you an example of how statistics may be erroneously interpreted I would call your attention to the article by Prof. A. H. White, formerly lieutenant colonel, Nitrate Division, Ordnance Department, which appeared in Chemical and Metallurgical Engineering, volume 22, page 370, in which there was produced a chart showing the consumption of by-product ammonia, cyanamid, and nitrate of soda, with projected consumption curves up to the year 1930. This curve of Prof. White's is reproduced here in plate 4.

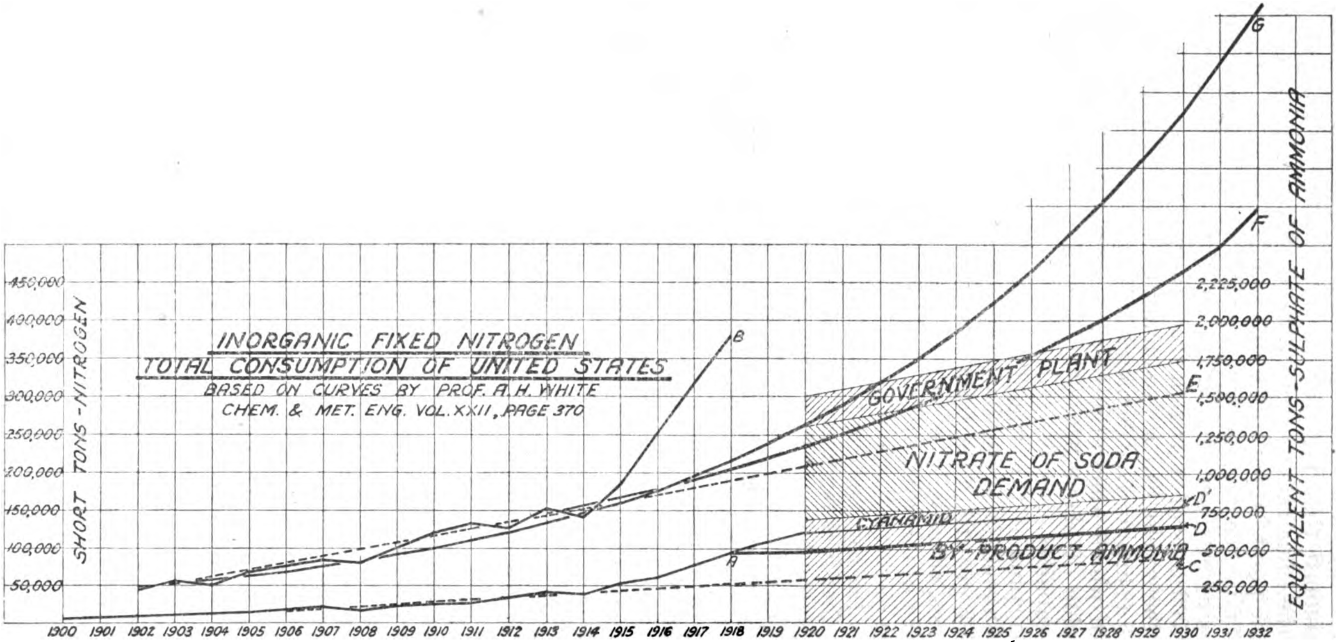
INORGANIC FIXED NITROGEN
TOTAL CONSUMPTION OF UNITED STATES
BASED ON CURVES BY PROF. A. H. WHITE
CHEM. & MET. ENG. VOL. XXII, PAGE 370
SHORT TONS - NITROGEN
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
EQUIVALENT TONS - SULPHATE OF AMMONIA
2,225,000
2,000,000
1,750,000
1,500,000
1,250,000
1,000,000
750,000
500,000
250,000
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
A
B
C
D
D'
E
F
G
GOVERNMENT PLANT
NITRATE OF SODA DEMAND
CYANAMID
BY-PRODUCT AMMONIA

PLATE IV

Up to the year 1914 the curve of Prof. White for total nitrogen consumption agrees with the chart which I have just called your attention to (plate 2). Between 1914 and 1918 the curve of total production of Prof. White ending at point B agrees with the line of total nitrogen consumption in my own chart. In projecting beyond 1914, Prof. White does not seem to be very clear as to how this should be done, so he makes several assumptions; in one case he assumes an annual cumulative increase of 7 per cent, based upon 1913 consumption, which gives him a curve ending at the point F. Not quite certain that this is the right way to treat this matter, he has drawn another projected curve of consumption based upon an annual cumulative increase of 10 per cent on 1902 consumption. I have just shown you that up until the outbreak of the war the average annual increase was a linear function and could be represented by a straight line which in my own chart (plate 2) is represented by the line APA. I further called to your attention the fact that the history of the industry showed that this straight line increase was the only true and logical one and that there was no law in mathematics which applies to this case and converts this straight line into a curve.

Nevertheless, Prof. White has made an application of mathematical principles whereby instead of arriving at the straight-line increase he actually determines this increase to be in the form of a sharply upward inflected curve. It is rather interesting to examine closely into the method by which Prof. White obtained this most suprising result.

In the years 1904, 1908, 1914 there were slumps in the quantities of total nitrogen used in the United States. These slumps were occasioned largely by business conditions. By joining the three points of abnormally low consumption for these years and projecting the same into the future to the year 1930, Prof. White obtains his sharply upward ascending curve which shows such surprising consumptions in 1930, amounting to roughly 675,000 tons of nitrogen.

Now, these abnormal slumps for the years 1904, 1908, and 1914 were occasioned by abnormal business conditions. Had conditions been more adverse than they were the slumps would undoubtedly have been greater and the entire projection of Prof. White's curve into the future, would have been very seriously affected. For instance, had the slump for 1908 been twice as great as it actually was, the consumption in 1930 as determined by Prof. White, might have been an infinite quantity of nitrogen. Had the slump for 1908 been less than it actually was, his curve would have materially flattened out and the consumption in 1930 would have been correspondingly lessened according to his method of projection. In other words, Prof. White bases the consumption of nitrogen in the United States in 1930 upon the business condition that existed in 1908, which, gentlemen, I am quite certain you must admit is an absurd method of development.

No one could possibly believe that the degree of business depression existing in 1908 will have any serious affect upon nitrogen consumption in 1930.

It is interesting to note that Prof. White has projected the line E, based on an assumption of the same annual increase throughout the period of discussion as existed during the decade 1902 to 1912. This line is essentially the same as my line of total nitrogen consumption and agrees with it very closely, which is quite natural, as they are both derived from the same data in the same way. The laws of mathematics governing projected curves can only be interpreted from the data existing to produce the line E in Prof. White's curve. Why he should attempt projection upon the basis of three short periods of abnormal industrial conditions to arrive at conditions 10 to 15 years after the latest of those depressions is a kind of logic which I can not fathom.

Let us now turn to the question of supply as graphically set forth by Prof. White. Prof. White assumes that in 1920 there was no more by-product ammonia capacity available than in 1918, although there is available in uncontrovertible statistical form an actual record of this by-product oven capacity at the beginning of the year 1920, which is largely in excess of the projection of such capacity made by Prof. White. In addition, he assumed that from 1920 on the by-product oven capacity for producing sulphate of ammonia would increase only at the prewar rate and did not take into account the fact that beehive ovens are being replaced in increasing numbers by by-product ovens, which fact would further completely modify Prof. White's method of projection.

The method of projecting the supply and demand adopted by Prof. White is one which is without logic and not supported by the principles of statistical analysis. It is undoubtedly aimed at showing the maximum possible demand and the minimum possible supply. If we take Prof. White's data for the supply of sulphate of ammonia and add to it the known capacity of ovens in existence in 1920, which were not incorporated in Prof. White's figures, and to these we add the imports of cyanamid and the necessary nitrogen in the form of nitrate of soda required in that form by industry and agriculture, the sum total will show a surplus of nitrogen compounds far exceeding the proper projection of normal demand.

The Government has presented a set of charts showing the consumption of inorganic nitrogen up to the outbreak of the war and during the war. They have projected a consumption curve for inorganic nitrogen beginning with the year 1919 and ending with the year 1930. In this projected consumption curve from 1919 to 1930 they have taken as a rate of increase almost exactly double the increase noted in the history of the industry from 1900 to 1915. There is absolutely no basis for such an assumption as this. All projections must be based upon past history. To show how inapplicable this projected rate of consumption would be if we assumed that same rate beginning with the year 1900 to apply, we would find that in 1915 the consumption of inorganic nitrogen would have been just double what it actually was. This projected consumption of the Government is manufactured out of pure assumption without relation to the history of the industry, and the conclusions that they base their argument upon, if applied to known data, will not reproduce the actual consequential facts.

Senator **Ransdell.** Is that ammonium sulphate, the product of the coke ovens, produced in the manner you have described, the same product that would be produced by this plant at Muscle Shoals?

Mr. **Washburn.** Exactly the same.

The CHAIRMAN. Can you tell us offhand what percentage of the total cost covers the production of this sulphate from the ammonia gas?

Mr. WASHBURN. What the additional cost is?

The CHAIRMAN. I mean for reducing it from ammonia gas to sulphate. What is the cost of that to the manufacturer?

Mr. WASHBURN. I will give you the figure you want, but I can not give it to you in the way you want it, for this reason: No one knows how to figure the cost of the ammonia. You see, it is a by-product. But the additional cost of converting it into sulphate is about $25 a ton.

The CHAIRMAN. Mr. Washburn, Mr. Kilburn Scott here wants to ask you a question or two.

Mr. SCOTT. Does it follow you need to buy this sulphate of ammonia from Chile? Is not the whole idea of having these industries in this country to cut that clean out? Was not the whole idea of having these air plants in this country to clean this right out, and would not that, if you had it, cut down the imports of the Chilean nitrate?

Mr. WASHBURN. The process that is in operation in the United States for the fixation of atmospheric nitrogen can not produce cheaply enough to manufacture the material at a cost at which you could make your nitric acid out of nitrate of soda from Chile. Now, there may be processes—your process may, or the Birkeland and Eyde process may, be able to make nitrate compounds that will take the place of nitrate of soda from Chile——

Mr. SCOTT (interposing). May? Have.

Mr. WASHBURN. And possibly they do.

Mr. SCOTT. Two hundred thousand tons a year.

Mr. WASHBURN. But that has absolutely no place in this discussion, because what we are discussing is a plant of a peculiar kind at Muscle Shoals, at a particular spot in the United States, with a particular process, that can not make nitric acid or anything that nitric acid goes into and do it as well as nitrate of soda to-day.

Mr. SCOTT. Why not?

Mr. WASHBURN. Because the process does not permit it; it has not the merit that enables it to do that under present conditions.

Mr. SCOTT. Shall I take this up later, Mr. Chairman, or shall I go on now?

Mr. WASHBURN. Suppose, Mr. Chairman, I finish this first.

The CHAIRMAN. If Mr. Washburn prefers to finish now, we will give you plenty of time, Mr. Scott—unless there is some particular question you want to ask now.

Mr. SCOTT. I would like to say simply that in the report of the nitrogen products committee, which has just been published by the British ministry of munitions, three copies of which I have seen in Washington, it is proved conclusively that the cost of producing nitric acid from the air by the arc process is half the cost of making it from Chilean nitrate.

Mr. WASHBURN. But, gentlemen, did you notice that he did not emphasize the word "arc"? I think I could show this committee, if it were worth while, why there might be some modifications of that report. But let us assume, now, that Mr. Scott's statement is absolutely correct. Like the flowers that bloom in the spring, it has nothing to do with the case, because they have not put the arc process down there; they have got the cyanamid process.

Mr. **Scott**. But they have the electric power there. You have a plant down there for making it by a process which Mr. Washburn now says is not good, which is entirely contrary to what he said in 1916. He said, "Put that plant up, because it will be a tremendous factor in the war." Now he is condemning his own plan. The reason it can not be used is that it reverts the phosphate—it spoils the material. But the nitrate does not spoil the phosphate.

Mr. **Washburn**. Mr. Chairman, I think the significance of Mr. Scott's introduction into this matter is entirely apart from the practical question that is facing us. I should be very glad—not only glad, but I shall insist, if the committee is willing to listen to extraneous matter here—that Mr. Scott's discussion be continued when we get through with the matter that this committee is at present considering.

The **Chairman**. Very well. Will it interrupt you if I ask you a question? Just in order to lay the foundation for what may transpire in the future, may I ask if Mr. Scott and yourself agree upon the figures which you presented here as to the partial use in agriculture? I think you said 150,000 tons?

Mr. **Washburn**. Yes.

The **Chairman**. And that the total amount used in agriculture and in the arts was 285,000 tons. Do you gentlemen agree as to what the amount was? This is rather an important question?

Mr. **Scott**. In 1914?

The **Chairman**. Yes.

Mr. **Scott**. I was not in the country then, so I do not know.

Mr. **Washburn**. Those figures come from recognized official documents.

Senator **Ransdell**. This ammonium sulphate in agriculture takes the place of the Chilean nitrate?

Mr. **Washburn**. It does not, and can not.

Senator **Ransdell**. Then what is it you are proposing that would take the place of the Chilean nitrate?

Mr. **Washburn**. There is nothing that can take the place of the Chilean nitrate, except the ability—if the ability exists—of the air fixation process, or some air fixation process, to make something that is the equivalent of nitrate.

Senator **Ransdell**. And that has not been developed yet, according to your theory?

Mr. **Washburn**. That we can not do with the process at Muscle Shoals. And, as we designed it and built it and operated it, and it has been our business for years, we certainly know something about it.

Senator **Ransdell**. Are they developing in other countries a nitrate compound which is very beneficial to agriculture, taking the place of the Chilean nitrate in agriculture?

Mr. **Washburn**. There is a hope that that can be done, but there is no accomplishment at the present time that supports that hope. The Norwegian arc process produces, not nitrate of soda, which is the Chilean nitrate, but nitrate of lime. It is a nitrate compound like the Chilean nitrate, only it is the question of combining nitric acid with lime instead of with sodium. That material has some serious mechanical limitations that the Chilean nitrate of soda does not possess, and the efforts to introduce it into this country have been wholly unsuccessful.

It is not anticipated among the practical men engaged in the great industry of agricultural fertilizers in this country that that nitrate will have any place here or can displace Chilean nitrates. But suppose it could. Let us assume, for instance, that Mr. Scott's process could come in here——

Mr. **Scott** (interposing). Not mine; the arc process.

Mr. **Washburn.** Let us suppose that the arc process could come in here and fill up this whole place. Let us assume that that could be done. That does not affect the use of ammonia, and it would not affect the surplus you would have in the present capacity and growing capacity in this country for producing sulphate.

Senator **Ransdell.** That is true as far as sulphate is concerned, but if this arc process be one that would give up a substitute, taking the place in agriculture of the Chilean nitrate, would it not be of immense value to this Nation?

Mr. **Washburn.** Undoubtedly.

Senator **Ransdell.** My reason teaches me that there is not an unlimited amount of the Chilean nitrate.

Mr. **Washburn.** But even if there were an unlimited quantity of it, if the arc process can come into this country and produce a substitute for the Chilean nitrate, God bless it, it ought to come here.

Senator **Ransdell.** I would think so. Your contention is that the scientists of the world up to date have not developed any process to make a fairly good substitute for Chilean nitrate. That is correct, is it not?

Mr. **Washburn.** No; I would not go that far. I would say that so far as practice is concerned, up to the present time there have been some practical limitations on the employment of the arc-process nitrate that have not permitted it to displace Chilean nitrates, but it may do so any day. It may do it in the next 10 years; it may do it in the next 5 years.

Mr. **Scott.** Did it before the war, sir? You know very well it did it before the war.

Mr. **Washburn.** And let us assume that Mr. Scott's belief is correct, that it did it before the war. Granting all that—not only granting, declaring it, if you choose—that has nothing to do with the fact that the Muscle Shoals plant is proposing to produce a material of which we already have in the world and in the United States an excess capacity over the possible use of it; and the further fact that the Muscle Shoals plant, for many reasons which I will come to before I get through, as it exists to-day, unless you put in a new process, can not produce any Chilean nitrate or any nitrate that will take the place of Chilean nitrate.

Senator **Ransdell.** It is not contemplated putting in this arc process that Mr. Scott speaks of?

Mr. **Washburn.** No. There would be some more millions.

Mr. **Scott.** We made nitrate of lime years before the war, and over 100,000 tons was sent to Germany and used by the German farmers. At the present time, in Norway, Sweden, and Denmark, by international arrangement, the farmers are using exclusively nitrate of lime, the material which Mr. Washburn says has physical disabilities. I say he knows it has not physical disabilities. It was shown before the war that it was a material that could be sent over and used by the citrus nitrate farmers down in California. It was sent 5,000 or 6,000 miles and competed there with the Chilean nitrate which only had to come up less than 2,500 miles. And he knows it.

Mr. WASHBURN. Gentlemen, in order that we may see what the significance of Mr. Scott's remarks is, I will grant that I know it. I will grant that he is correct. We will say it is true that that material has shown its superiority and that it can come over here and take the place of Chilean nitrate. But that has not anything to do with the case. That is the point. Now, I have not any quarrel, and never have had, with the arc process.

Mr. SCOTT. You have spoken about it many, many times in a very reflecting manner before institutions and before these Houses.

Mr. WASHBURN. I think you, Mr. Chairman, knew Mr. Eyde, did you not?

The CHAIRMAN. Yes.

Mr. WASHBURN. The first process that I tried to secure for this country was the arc process. I reviewed with Mr. Eyde and his financial director in a number of conferences this whole question of a future situation, as it was then, of fixation in this country. We agreed when we got through—his opinions and mine were the same. These were the words of Dr. Eyde, as nearly as I can remember them. In the nature of things, I can not remember the words correctly, but I remember the statement and the significance of it. He said, "Mr. Washburn, the arc process has no place in America, and in my judgment never will have."

The CHAIRMAN. That is really due to the fact that it takes more power than the other processes? That is one of the factors?

Mr. WASHBURN. That is one of the factors. It is an enormous field, and if it could be occupied the people that would be most interested in occupying it, the people whose very salvation would depend upon using it, would be the American Cyanamid Co. We do not care one thing about the cyanamid process.

Mr. BOWER. Mr. Washburn, you had here a few minutes ago a chart that was subsidiary to this one, showing the cotton situation after the Civil War.

Mr. WASHBURN. Merely to show that following the war some things dropped down instead of continuing upward. That is all.

Mr. BOWER. Mr. Washburn, is it not true that at the close of the Civil War the increased use of fertilizer in the Southern States was practically their salvation, and that immediately after the close of the Civil War was when the fertilizer industry in the South really made its great beginning and took its economic place in the production of cotton?

Mr. WASHBURN. I imagine that is so. In any event, the success of cotton growing depends upon the use of fertilizer.

Mr. BOWER. Yes; and that was especially emphasized by the condition the South found itself in at the close of the Civil War?

Mr. WASHBURN. Yes; and there were other reasons. The farms were destroyed, labor taken away, and so on.

Mr. Bower. Yes; but fertilizer is a great labor-saving device for the farmer?

Mr. Washburn. Absolutely.

Mr. Bower. My thought was that possibly—and I think it is reflected by Senator Gronna's remarks—that the acreage of wheat and the agricultural situation over the country shows that a similar condition is arising at the close of this war, which possibly may increase the demand here beyond this prewar average. You take our present labor conditions on the farm; we have to meet that situation somehow, and the easiest way is through the use of fertilizer. So I am just suggesting that possibly this average may go up.

Mr. Washburn. Yes; it is possible.

Here is the world curve, and there is the development of the curve published in the Chemical and Metallurgical Engineer [exhibiting plates 3 and 4]. I do not know, but I think I might put that in with an argument on it, without taking the time of the committee.

The Chairman. What is that second chart there, Mr. Washburn?

Mr. Washburn. This is the chart that was published in the Chemical and Metallurgical Engineer, showing what they consider to be the field that the by-product oven could occupy, or rather that sulphate of ammonia could occupy. Instead of continuing the line of use, they drew a curve showing a very gradually increasing use, and they based that curve on the amounts in use here prior to 1914 and in 1914, which, it so happens, were consumptions that were determined very largely by financial depressions in this country. An interesting thing, showing the fallacy of drawing a curve in that way, is that had there been a greater financial disaster in 1907, reflected in still less business in 1908 than actually occurred, then according to the logic of this curve it would have resulted in the use of more ammonia for all time to come. The ridiculousness of the idea that a financial disaster in 1907 could affect the use of sulphate of ammonia, for instance, in 1930 or 1940, or any other time, is apparent on the face of it.

Another anomaly about a curve of that kind is that if you follow out the law of the curve you will find that it would mean increasing your consumption each year indefinitely until it runs into the billions of tons in a short time.

There [indicating] is the world curve. I merely point out that here is the surplus capacity to-day that is practically agreed upon, over the present consumption. Here is the known consumption, and there is the excess capacity.

The Chairman. That is how many tons?

Mr. Washburn. That is, in nitrogen, about 900,000 tons, which is equivalent to 4,500,000 of sulphate. But that is in nitrate and sulphate both. And here we have 3,000,000 tons of sulphate of ammonia in excess of a present use of 4,500,000 tons.

Mr. Scott. And yet the farmers are buying more fertilizers than ever before, not only in this country but all over the world. They are being bulldozed by the fertilizer manufacturers—another reason why you should start the Muscle Shoals plant.

Mr. Washburn. Gentlemen, I am coming to the question of the cost of fertilizers, but I would like to refer to it here because it has been called to your attention. When you come to the consideration of the cost of almost anything at the present time, we think that one thing is high; but sulphate of ammonia, on the price that has just been quoted, of $4.50 per 100 pounds, is barely 50 per cent more than the normal price. The normal price has been around $3.25, as I recall it, and that has now gone up to $4.50.

The CHAIRMAN. The cost can not be based upon any one single thing; there are so many things that enter into it.

Mr. WASHBURN. You can put it this way: You can say your dollar is worth only 50 cents; and if it is worth only 50 cents, why should it to-day purchase an article for $1 that formerly cost $1 when for any other article you would have to pay $2?

Mr. BOWER. Since when has it dropped to $4.50?

Mr. WASHBURN. That is the price fixed for next season.

Mr. BOWER. This season it has been around $7 to $7.25 nominally, with an export price of $7.50.

Mr. WASHBURN. That is the top, about $7. But you must remember that the high price of the sulphate, domestic, has been for spot quantities, and a very small quantity.

Mr. BOWER. It has all gone abroad; it has been exported.

Mr. WASHBURN. Yes; the export market is now declining. The vast quantity of sulphate which goes into fertilizer, 90 per cent of it, carries the price that is made when these big contracts are made; and the big contracts this year will be made at $4.50, which is barely 50 per cent higher than the old days.

Senator RANSDELL. I did not hear you yesterday. Did you suggest anything as a substitute for Chilean nitrate in agriculture?

Mr. WASHBURN. No; I suggested nothing as a substitute for Chilean nitrate, because I do not know of anything which is a proved substitute for it. But we can not substitute ammonia nitrogen for Chilean nitrate or nitrate nitrogen. There are two different kinds of nitrogen compounds. One is the nitrate which acts quickly in the soil without the necessity of going through bacterial action; that is known as nitrate nitrogen. Examples of nitrate nitrogen are the Chilean nitrate and the calcium nitrate, made by the arc process.

Now, the kind of nitrogen that comes from the by-product ovens, the only remaining kind, and the kind that comes from cyanamid can not invade that field of nitrate nitrogen. And as the Muscle Shoals plant is calculated to produce economically only ammonia nitrogen, there is not any place in the field of nitrate nitrogen or Chilean nitrate that the Muscle Shoals plant can enter.

Senator RANSDELL. I have understood that these additions which are proposed by this Wadsworth bill would give us what we call nitrate nitrogen or calcium nitrogen. Maybe I do not understand the bill, but that is what I thought was the real matter before us—that we are to spend a considerable additional sum of money to make available the water power there for that big plant.

Mr. WASHBURN. Yes; to make available the water power for the production of sulphate of ammonia, which is ammonia nitrogen.

Senator RANSDELL. Why not make available that water power for the calcium nitrate?

Mr. WASHBURN. Because if we did we would have to put in a calcium nitrate process.

Senator RANSDELL. Well, would that be impossible?

Mr. Washburn. Impossible at the cost of power down there; it would be enormous.

Mr. Scott. But the cost of that power is going to be less than in Norway and Sweden.

Senator Ransdell. I have always understood there was a tremendous water power there; something like 15,000 horsepower, I have heard.

Mr. Washburn. Let us consider what the cost of water power is. They are proposing now to spend $25,000,000 for a 100,000-horsepower plant. That is $250 a year per horsepower. Let us assume you could use all of it right straight along throughout the year and have no losses from idle time or anything of that kind. Five per cent on the cost of your power—nothing else; just 5 per cent—is $12.50 a horsepower year. And yet these gentlemen in making their estimates have referred to $1.69 for power in one case, and in another case about three times that amount.

It is true they did not intend to cover the interest when they mentioned those amounts, but to talk about a cost of $1.69 a horsepower year is so misleading that the mind gets to operating on the basis of $1.69 and forgets that the interest alone that this Government has got to pay out, in this period of the highest taxation it has ever known, will be $12.50 a year per horsepower.

My estimate of the cost of producing hydroelectric power at Muscle Shoals is as follows. I have assumed that the steam plant will be carried as a stand-by and no fixed charges are to be made on its investment, but a maintenance charge as noted below is included. I have further assumed that hydroelectric plant will be operated at full load of 100,000 horsepower equal to 75,000 kilowatts.

Cost of power:		
Administration and labor		$100,000.00
Maintenance and supplies		60,000.00
Depreciation, obsolescence, insurance, and extraordinary repairs—		
Power house, dam, and lock		408,900.00
Equipment		251,500.00
Contingencies		60,000.00
Interest 5 per cent		1,250,000.00
Steam plant stand-by:		
Maintenance	$25,000	
Supplies	15,000	
Heat and light	7,500	
		47,500.00
Total		2,177,900.00
Cost per kilowatt-year		$29.00
Cost per horsepower-year		21.77
Cost per kilowatt-hour		.0033

Senator Ransdell. What would follow from that?

Mr. Washburn. It will follow from that that the cost of your water power down there is going to be somewhere in the neighborhood of $20 or $25 per horsepower year.

Senator Ransdell. Would that be prohibitive?

Mr. Washburn. Absolutely. It is not only prohibitive, Senator, but here is the crime in that thing: About 90 per cent of the cost of that water power down there is in interest and other percentage items that depend upon cost. Think of it for a moment. I go out here to a customer with power, and I say, "Mr. Customer, please buy my product from me." "Well," he says, "tell me a little about what your costs are. What does it cost you?" I say, "I am going to give it to you for just the cost, and I am going to tell you what the cost of it is. Nine dollars is in interest and depreciation and other items that depend upon cost and vary with the cost pure and simple, and $1 is in all the other things—labor, raw materials, supplies, and everything else."

"Well," he would say, "when did you put in that plant?" "Oh, I put it in when costs were right up at the top, when labor was the most expensive ever known, when materials were the most expensive ever known." "Well," he would say, "why didn't you build it when labor and materials were normal, say about half what they were when you did build it? Then your power would cost you only half as much, would it not?" And I would have to say, "Yes."

That is the Government's position to-day. They not only propose to build the Muscle Shoals hydroelectric plant at a time when the taxes are the highest, and put $25,000,000 into that item alone, but they propose to do it when labor and materials are the highest this country has ever known. And that is in a proposition, gentlemen, in which normally the interest and fixed charges are 80 per cent of the total cost of the article after it is finished, which in this case is power.

And that is not the worst of it. They might even do that, but that does not tell half the story. You can just drop that out of your mind in view of this consideration, that they have already got a power plant there that will produce the power for that plant and produce it at Government expense at no greater cost than their water power after they get it. I would like to have that challenged, because if that is true you gentlemen can not get by it.

Assume steam plant exists as is and that depreciation and interest will amount to essentially the same thing whether the plant is operated or not, inasmuch as maintenance and supplies will keep the plant in first-class operating condition. Under these circumstances the actual cost of power when the plant is operated over and above the cost of carrying the power plant in idle condition, will be as follows:

Coal, 394,000 tons, at $4.65	$1,830,000.00
Administration and labor	120,000.00
Maintenance and supplies	100,000.00
Total	2,050,000.00
Cost per kilowatt year, excluding fixed charges	34.16
Cost per horsepower-year, excluding fixed charges	25.62
Cost per kilowatt-hour, excluding fixed charges	.0039

Senator **Ransdell**. Assuming that is true, could they inaugurate the arc process with this power that they now have there; and if so, how expensive would it be to inaugurate that arc process?

Mr. **Washburn**. They could not inaugurate the arc process and, within my knowledge, there is nobody who would for a moment contend that it could be done. The arc process is completely and entirely out of the field of discussion, so far as this situation is concerned.

The **Chairman**. Mr. Roberts, who appeared before the committee, stated very clearly that interest was not taken into consideration in the figures.

Mr. **WASHBURN**. Yes; and you will remember that I stated, Mr. Chairman—I stated that interest was not taken into consideration. But the fact that he does not take interest into account does not indicate for one moment that good old Uncle Sam has not got to pay interest on the money he puts into that power plant.

The **CHAIRMAN**. I agree with you absolutely. We ought to consider interest and taxes and figure it upon a sound business basis. I agree with you on that.

Mr. **WASHBURN**. How long would a corporation in this country live that at the very topmost rung of the cost of building power plants would go in and build that power plant when they already had power just as cheap that was standing idle?

The **CHAIRMAN**. At what price per horsepower would the Government be able to furnish power at Muscle Shoals after it was completed?

Mr. **WASHBURN**. If the Government attempted to develop the power at this time and furnish power in there at bare cost, it would be somewhere in the neighborhood of $20 a horsepower year.

The **CHAIRMAN**. That is about four or five times as much as it costs them in the Scandinavian countries, I understand; four times as much, anyway.

Mr. **WASHBURN**. There are a few Scandinavian powers that can be had very cheaply. If you figure the Scandinavian power at $10, that is about as favorable as you can get. There are a few exceptions, but that figure is good enough for general use. That is only a part of the story, however.

The **CHAIRMAN**. It is now 12 o'clock, and I suggest that we take a recess.

(Thereupon, at 12 o'clock m., the committee took a recess until 1.30 o'clock p. m.)

AFTER RECESS.

STATEMENT OF MR. FRANK S. WASHBURN—Resumed.

The **CHAIRMAN**. Mr. Washburn, you may resume.

Mr. **WASHBURN**. It is not always easy for me to know what is in the minds of a member of the committee, even when he asks a very simple question, and I think this morning I failed to understand one thing that Senator Ransdell wanted to know. He wanted to know why we could not manufacture nitrate of soda at Muscle Shoals. Well, we can; we can make nitrate of soda at Muscle Shoals, but it will cost about $82 a ton, and that is without charging interest on any of the present investment, and the market is a shade under $80.

The **CHAIRMAN**. There would be nothing saved?

Mr. **WASHBURN**. There would be nothing saved; no.

Also, this morning the question was raised as to the price of sulphate, and that raises the question that often puzzles one in considering markets, the difference between what is called the spot price and the average price that the industry pays for a thing. Last year when the contracts were made which will cover 70 per cent to 80 per cent of the sulphate used in the manufacture of fertilizer, they were made on the basis of $3.50 a hundredweight, which you see is only 25 to 50 cents above the peace-time price, and that was last year. Now, this year the price has gone up a dollar a hundred, as I stated before, up to $4.50; but if one looks in a trade journal he may find a quotation of $7. It is just a spot price, and only applies to a small quantity—and the price on exports has been pretty generally $7.

The by-product coke-oven industry has been pretty broad in its conception of prices. They felt it necessary, I judge, from what I have observed, to use a great deal of reserve in fixing prices on sulphate, and I think some reserve is shown by the fertilizer industry in the use of the materials which they make up before delivery to the farmers, because, as you remember, in that famous investigation made by the Federal Trade Board, and its report in 1916 or 1917, I have forgotten which, they showed—after examining the books of the large fertilizer concerns of the country—they showed that their profit was about 6 per cent upon their property, upon their investment, and they did not include in the investment large holdings, which many of those companies feel it is necessary to have of raw material, like phosphate rock properties, and so forth. Merely taking the properties and capital that were in use they found that the business returned about 6 per cent on the money. I merely mention that to relieve the impression that sulphate of ammonia has gone from the peace-time price of $3 or $3.25 to $7.

Nothing has been said to you about the quantity of cyanamid fertilizer which the United States market will absorb; but it has been said to you by the Government representatives, that they might possibly desire to make some cyanamid, and they spoke of a quantity of something like 35,000 to 40,000 tons, as I recall it. Now, I will refer to the fact that that would require some arrangement between the Government and the American Cyanamid Co. But even if it did not require any arrangement beyond what has already been made under our contract, the quantity is so small, being only about 15 per cent of the capacity of the plant, that even if they filled the whole fertilizer market of the United States with cyanamid and the American Cyanamid Co. had none of it, and was just pushed out completely, it would only take 15 per cent of the capacity of that plant to fill it. Now, there are very good reasons why that limited quantity can not be increased in the market. That is due to the limitations in the quantity of cyanamid used in the fertilizer itself.

Senator Kendrick. Do you mean to say that it could not be increased without demoralizing the prices?

Mr. Washburn. No; even the prices were demoralized, and in spite of the fact, Senator, that the American Cyanamid Co. has in the 13 years of its life paid only 6 per cent dividends upon the money invested—not upon the stock, but upon the actual money invested—and has very energetically pushed cyanamid fertilizer in the market of the United States, and in spite of the fact that the price of it has been materially less per pound of nitrogen than has been the price per pound of nitrogen in sulphate of ammonia, which is the next most expensive material, this market in this country will be saturated with 36,000 tons—in any event it will not exceed between 36,000 and 40,000 tons.

Senator Kendrick. Then you men, Mr. Washburn, that the market will not absorb it?

Mr. Washburn. The market will not absorb it, and there are very good practical reasons why it will not absorb it, and the strongest practical reason is that it can not be used in mixed fertilizers except in very limited quantities without affecting unfavorably the other materials with which it is mixed, or one other material with which it is always mixed, and that is the acid phosphate. Had the Cyanamid Co. sat back and accepted that limitation as a limitation on their business, why we would have a very small and negligible item in the business of this country; but we have—as soon as we recognized that situation, which it took us time to recognize—from that time we began devoting our attention to other uses for cyanamid. The world did not have any other uses, but through cooperation with technical commissions abroad and our own department of technology, our research department here, we have developed uses for cyanamid, using it as a raw material in the preparation of other things. Of course, on all those things, which are relatively late development, we have controlling patents; but that is a field entirely our own, entirely outside of agriculture—well, one of the important fields is in agriculture, but it is very largely in the arts and other chemical industries.

Sulphate of ammonia is the material which we all agree is the one which would be produced at Muscle Shoals if the plant ran. If you will recall the testimony that was in these—the testimony of one of the witnesses that you showed us last night—a Government witness, possibly the principal Government representative in this matter, it said:

> I think we will overcome the disability of cyanamid. Of course, that is a hope; but our dependence in coming to you to operate the plant is sulphate of ammonia, and we are basing our life upon that. We are not basing it upon cyanamid at all.

The Secretary of War, you will recall, stated that cyanamid is not a great fertilizer, and he did not share the optimism of his colleagues as to marketing cyanamid in very large quantities.

Another witness expressed the hope of bringing to success a method of making phosphoric acid in an electric furnace, combining this with nitrogen to produce ammonium phosphate.

Sulphate of ammonia, however, is the product which the administration plan covers and for which an appropriation is asked and of which the Secretary said, showing the administration point of view, that by adding to the plant in the way of sulphuric-acid equipment ammonium sulphate could be made, which was just like so many gold dollars in the fertilizer market and which could be sold in almost unlimited quantities.

The Government, like the individual, is without the right or power to infringe patents. The right of the Government to manufacture at Muscle Shoals is exclusively the right delegated by the American Cyanamid Co. in contracts made with the Government by the American Cyanamid Co. and the Air Nitrates Corporation, and bearing date of the 8th of June, 1918. At the moment, however, it is pertinent to say that the patents under which the Government is licensed to manufacture are specifically set forth in the contracts by number, date, and title. These patents do not include cyanamid fertilizer or phosphoric acid by the electric furnace or any other process. The patents owned by the American Cyanamid Co. are absolutely fundamental and controlling in these fields. We have been at work for years in these two fields with a skilled and able research department, collaborating with the cyanamid technical commission abroad. The suggestion on the part of one of the witnesses who appeared before you that the Government might with impunity proceed to manufacture under these patents is without even a shadow of right. Incidentally, an estimate made in February, 1919, indicated that $20,000,000 ultimately might be required to provide a phosphoric-acid plant of a sufficient size to consume in ammonium phosphate the normal quantity of nitrogen capable of being produced at the Muscle Shoals plant. We may, therefore, confine ourselves to what the Government's witnesses have testified to as being the only practical material which the plant can produce, namely, sulphate of ammonia.

Now, we come to the question, having laid the foundation here of the facts, as I believe they exist technically and commercially, to what the effect would be under these conditions of operating that plant. In this connection, first of all I would like to read an extract from a newspaper commenting upon an interview with one of the Senators here in Washington, and reporting the interview, purporting to give it as it was given:

> As I understand, the farmer organizations, with all their leaders and experts, have unanimously reached the conclusion that their only hope for freedom from the monopolistic control of the fertilizer trust is through the operation by the Government of the Muscle Shoals plant. If this is true, there can be no doubt that agriculture has suffered keenly through the manipulation of the fertilizer market.

That is too comprehensive an idea of what the Muscle Shoals plant is on the part of the gentleman who gave the interview. I think we can all see that now—we can all see now whether that is a fertilizer plant down there or not; but the point is this: In the testimony given before your committee here by the Secretary of War, and in answer to a direct question on the part of the chairman, he stated that the Government was not to deal directly with the ultimate consumer, that is, the farmer, but should make its products available through the regular channels of distribution. Now, that is the purpose; and somewhere else, if I remember correctly—I have only had the slightest opportunity of going through the testimony—but I think elsewhere the witness referred to it as the purpose of the Government to put its products out through the regular channels, seeing that it could not have agents scattered out all over the country.

Now, even if it were practical for the Government to dispose of the products of the Muscle Shoals plant directly to the ultimate consumer, it would not relieve the ultimate consumer from dependence upon the regular channels of trade so far as his fertilizer is concerned; and I am going to examine now and try to find whether, if the Government took its product of Muscle Shoals and put it out through the regular channels, and attempted to get it into the hands of the farmer, the farmer could use it. First, if we should overcome all of these disadvantages in the hope of doing something to help the farmer, the farmer could not take it and use it for this reason; of the annual consumption of fertilizer by farmers in the United States, measured in dollars—and I have taken the year 1913 as an example, for the reason that in that year we used an unusually large quantity of sulphate, so that these remarks would apply more seriously to an average year than to 1913; but taking 1913 as an example, 15 per cent was in potash, 29 per cent in phosphoric acid, 46 per cent in nitrogen compounds, consisting of nitrate of soda and various organic materials, and 10 per cent in sulphate of ammonia and cyanamid. Therefore, if the Government should supply the entire quantity of sulphate of ammonia and cyanamid consumed by agriculture in the United States to the farmer, the farmer would receive in this way only those materials representing 10 per cent of the total cost of his fertilizer, leaving 90 per cent still to be furnished by the fertilizer manufacturers through the ordinary channels of trade.

Now, if the Government should offer to furnish the products from the Muscle Shoals plant to the farmer direct, for other reasons than the fact that there would be very little sense in his taking this small proportion that way, he could not and would not take the material from the Government, for if he did take it separately, either he would have to go to the expense for the sake of only 10 per cent of his total materials of mixing them with the remaining 90 per cent that he had gotten through his ordinary trade channels, or, what would be still more expensive to him than trying to make that mixture between the 90 and the 10, he would have to apply this 10 per cent to the soil by a separate application, and applying fertilizers to the soil is measured—the cost of it—by the number of applications and not by the quantity at any one application. So that it would cost him about as much to apply that 10 per cent received from the Government as the 90 per cent that he had gotten, necessarily, through the ordinary channels of trade.

Now, both of these things are highly impracticable for the farmer, either to take 10 per cent and mix it with the 90 per cent or to take the 10 per cent and make a separate application to the soil.

The CHAIRMAN. I do not know that I ought to ask you to go into this; but just for my information, Mr. Washburn, if you will be kind enough to answer it, would you state briefly what other products go into this fertilizer, and where the farmer will have to apply, or the concerns that handle these other products—the 90 per cent product? Leave out the 10 per cent of nitrate of soda altogether. Where would the farmer have to go to get the other 90 per cent?

Mr. WASHBURN. If he tried to get the separate materials?

The CHAIRMAN. Yes.

Mr. WASHBURN. Well, he would go to the nitrate agency for his nitrate of soda, and he is being supplied by the nitrate agencies to-day, directly, to the amount of about—a little less than 40 per cent of the total amount that he uses. The farmers to-day, in this country, are receiving a considerable amount of nitrate of soda as a separate material directly from a trader, and to a large extent all the nitrate that he uses as top dressing, so if he wanted to get all of his nitrate of soda that way, that which goes into his mixed fertilizer as well as that for top dressing, he would undoubtedly go to the same concern. That is where he would get his nitrate of soda. His cyanamid he would probably get from the Cyanamid Co. His acid phosphate I have no doubt would be sold to him by the producers of acid phosphate, of whom there are a great number in the United States, beginning with the great concerns like the American Agricultural Chemical, Virginia-Carolina, International, and so on down. There are, very probably, 150 concerns making acid phosphate.

The CHAIRMAN. That is made from phosphate rock, as I understand?

Mr. WASHBURN. Using phosphate rock; yes. He would receive his potash, if we again establish relationship such as would give us potash from abroad, which is the only commercial source—he would have received that in the old days from what is known as the Potash Syndicate, which is a German owned concern, and under the new conditions he would receive it possibly from the importers.

Then, the long line of organics; there are traders in fish, traders in tankage of various kinds, traders in the largest part of the remaining material, namely, refuse from the street; it would be a little difficult to say just how he would receive that. Of course, one has to imagine somewhat of a change in method of vending those materials, because now they are sold in large amounts to large users, who are manufacturers, and we would have to find some way of retailing those out of the hands of the present dealers in raw materials.

The CHAIRMAN. In any event, the farmer would have to apply to these concerns that are now making that a business?

Mr. WASHBURN. To a considerable extent; but he could also compete in purchasing those materials with the manufacturer, so to speak, with the fertilizer manufacturers, by going to the man who makes the raw material that the manufacturer uses, which is the material that the farmer would use. Now, if this home mixing, as it is called, is what you inquired about——

The CHAIRMAN (interposing). That is what I have reference to.

Mr. WASHBURN. Toward bringing that about, efforts have been made in the way of the education of the farmer on the part of various agricultural departments throughout the country to show him ways by which it could be done and to urge upon him the advantages of it. It has not made very much progress. It is somewhat opposed to the whole tendency of American life and industry. We are engaged to-day in the package business. Instead of you and I buying for our households to-day soda crackers that are in a barrel—and we used to go in and buy 2 pounds, and they were put up in a piece of brown paper—we go into a store to-day and we see a pile of packages of Uneeda biscuits. They are nothing but the old soda cracker, and in buying them you do not get nearly as much for what you pay as you would if you took your soda crackers out of the barrel in the old way. Yet, our households refuse to buy otherwise than by the package business. It is so in the flour trade. We used to buy a barrel of flour; now we get a little package; and so it goes. City life has largely contributed to that, because people living in the cities do not have places for storage.

Now, our farmers are keen to buy the ready-made fertilizer. Some people have used the foreign practice, as an indication that we may in this country follow the foreign practice, which is the home-mixing practice to the extent that possibly over 60 per cent of the fertilizer is home mixed in Europe (maybe as much as 65 or 70 per cent), while in this country only about 15 per cent is not furnished as a mixed fertilizer. Home mixing is so small that we do not know what percentage it would be. But there are very marked differences.

between agricultural conditions in this country and in Europe bearing on that proposition. The agriculturists abroad, as a rule, live in little communities, villages. You do not see farm houses scattered out on the farms to the extent you do here. Occasionally, you find them outside of the villages, but even then they are rather close together. As a rule, they live in a little community and go out to their farms, this custom coming down from the old days when they had to live in communities and throw a wall around themselves to protect themselves from robber bands.

The CHAIRMAN. And they still operate, through their association?

Mr. WASHBURN. Yes. Already living together, you might say, in a cooperative way. Then, the amount of fertilizer used per farm is much more than the amount used here. Now, the purchaser of fertilizer, the individual purchaser, buys only what he uses on his own farm, and the average in this country on the farms east of the Mississippi, and we need not consider the farms west of the Mississippi, because broadly speaking there is no fertilizer used there—east of the Mississippi only 1.8 tons used per year. Now, for the farmer to sit down on such a small average as that and go to collecting these—I do not know how many dozen other materials, and attempting to mix them, he finds, in the very nature of things, it is not practicable. So, it is better that he should have the mixed fertilizer.

But there is another aspect of it that may have a bearing here, and that is that the mixed fertilizer for any particular section or for any particular crop is the result of a great deal of experience. I mean, a particular kind of mixed fertilizer; the proportions that it should have of potash and phosphoric acid and nitrogen, and our mixed fertilizers vary in their proportion of those three articles tremendously. And they not only vary in the proportion of those three, but they vary very much in the amounts of nitrogen that are used in proportion. You may find that one crop—take tobacco—takes something very different from another crop.

A tobacco crop takes a very different fertilizer than that for a potato crop. Now, there is a great deal of intelligence crystallized and wrapped up in that fertilizer, that peculiar fertilizer, that the manufacturer sends out. For tobacco, for instance, if the tobacco farmer should try to use as little organic material as the truck gardener uses, he would find that he was getting a tobacco leaf which was pulpy and thick, and that was acrid when he smoked it; but using a great deal of organic material, and drawing out the development of that tobacco leaf just as long as possible, and just as late in the season as he can, he gets a thin, hard, tobacco leaf which, when dried and prepared for use, is an excellent article to smoke. So, by the use of mixed fertilizer the farmer can secure the thing which the combined intelligence of the farmer and the mixer both indicate, have proven the best thing for that crop, while if he undertakes home mixing he would have to get that knowledge out of books, and then buy his materials in just the right quantity. He would have a dozen materials, it might be, in a few tons; that would be a few hundred pounds of each. He could not get it at carload lots and would have to get it in small packages. And then when he came to mixing it, what would the situation be? Plant roots receive their sustenance from a fertilizer by drawing it from a very limited distance. In other words, you have to place your fertilizer pretty close to your rootlets, and therefore if there is somewhere in a poorly made mixture some part of a number of materials, then that mixture will show poor results. That is, every part of it should have just the same proportion as another part of these various kinds of material.

Now, these fertilizer manufacturers strive every year to improve their mixing appliances, so as to get a uniform mix. And it is not easy; the materials have different weights, and they all have different sized particles. You see a pile of sand thrown out on the street, and you see all the coarse particles are at the bottom. Now, if those large and small particles have a different value, unless you have just the right kind of machinery to make a uniform mixture, you would not have the average of the materials that were mixed, but you would have too much of some one material in a particular place. So, the farmer, by the use of a shovel on the barn floors, which is the ordinary way when he does home mixing, is doing far more damage to himself by not getting a suitable fertilizer than is involved in the extra price that he would have to pay to have someone else do the mixing for him.

The CHAIRMAN. It is likely to destroy his whole crop?

Mr. WASHBURN. I do not think it would destroy his crop; no. He would still have value, but he would not have the same degree of value. I think if we ever got anything like universal home mixing that small mixing machines would be developed, and the farmer would improve in that way. But I am merely giving you the practical side of it. I am not arguing for or against home mixing. You asked the question.

The CHAIRMAN. Yes.

Mr. WASHBURN. In Europe, on account of the relatively greater abundance of farm labor, it is entirely practicable to obtain the single fertilizer materials and either apply them separately or mix them just prior to application. The cooperative organization which buys the fertilizer materials for its members also provides recommendations for mixing and applying the fertilizers, if needed.

In the United States in certain highly developed agricultural regions the granges very often follow a similar practice. For the individual small farmer, however, using only two or three tons of fertilizer and living largely to himself, the appeal of the ready-to-use mixed fertilizer will undoubtedly always prove stronger than any amount of argument in favor of home mixing. Americans have become so accustomed to buying ready-to-use commodities to satisfy their every need that it is doubtful whether they will ever relinquish their preference for ready-to-use fertilizers.

There is a situation with reference to costs in the testimony given by the Government—by the administration, that is not right clear to me; but I gather from the Secretary's testimony that he expects to make material at about 20 per cent cheaper, in any event, to deliver about 20 per cent cheaper than ordinary prices. If the fertilizer manufacturer received all of his ammonia nitrogen—all of it—from the Muscle Shoals plant, and it would be cheapened to him by the extent of 20 per cent, of the total cost to him of his manufacturing it would represent only 20 per cent of 7 per cent on the total cost of mixed fertilizer to the manufacturer. This includes all materials and his labor; only 7 per cent of it is in sulphate, and therefore, if he received his sulphate 20 per cent cheaper from one concern than another and received it all from that source, which we will say now is the Government source, his mixture would be cheapened by 20 per cent of 7 per cent which is 1.4 per cent.

Now, it is reasonable to suppose—I am dealing with this from the standpoint that all people in trade have to look at it, I mean the commercial standpoint—this is not an engineering problem essentially—the engineering and technical end is a very small and unimportant one; it is the commercial and economic standpoint that is important. Therefore, the most that would be done for him, if he received all the material from the Government, would be that the cost of his product would be decreased by 1.4 per cent. Now, no one could anticipate for a moment that the Muscle Shoals plant could furnish the fertilizer manufacturer with all the sulphate that he would use in the face of the competition of a by-product which must be produced anyway. Let us take a very exaggerated conception, that the Government furnished two-thirds of the sulphate of ammonia used in the fertilizing industry.

Then, the result of the fertilizer manufacturer dealing with the Government and receiving the advantage of what the Secretary believes is to be cheap production, the advantage to him would be that the cost of his product would be cheapened by 1 per cent. Now, how is that saving to be carried from the fertilizer manufacturer over to the farmer? It is too small to be traced. It would mean that the fertilizer industry of the country would have to establish, as far as I can see, by a Government dictum, what the price of their fertilizer ought to have been if they had not bought from the Government, and then take 1 per cent off of it. But there is not any conceivable way, I think, whereby a manufacturer, by reason of purchasing from one producer rather than from another, and thereby manufacturing somewhat more cheaply, could undertake the obligation to give his customer the 1 per cent advantage. It would be wholly impracticable. And even admitting that it was his honest purpose to give it to the farmer, and that he would do it without any control, I do not see how it could be done. But certainly some control of this great competitive situation, in which these fertilizer manufacturers meet each other, would have to be exercised if, on so small a margin as that, it wanted to be absolutely certain that the saving was carried over from the manufacturer to the farmer. It would have to place the manufacturer under bond, or involve some such obligation. That is going away outside of the fields of practicability.

In order to avoid just as many steps of discussion as possible, let us assume that the fertilizer manufacturer did carry that advantage of 1 per cent over to the farmer—suppose the farmer got it all. What would it mean to the farmer? Now, the average use of fertilizer on the farm we say is 1.8 tons. The price before the war ran from $20 to $22 a ton.

Senator KENDRICK. May I ask a question there in connection with your statement that the advantage would only represent 1 per cent? Is that it?

Mr. WASHBURN. Yes.

Senator KENDRICK. Do not you think it possible, and even highly probable, that the fact that the Government was producing this material, involved in the delivery of it to the farmers at a moderate price, that it would have salutory, if not a definite effect, upon the price of it to the farmers? That is to say, it would have a tendency to hold the price down throughout the country?

Mr. WASHBURN. If we assume that it had the effect of holding the price of all sulphate down to the Government price, instead of that being 1 per cent it would be 1.4 per cent. That is the effect it would have.

Senator KENDRICK. Well, my question——

Mr. WASHBURN (interposing). Have I answered?

Senator KENDRICK. Well, I had not made my point clear, I think. My idea is that without such an influence in the market as the Government producing—well, we will say, for the dual purpose of profit and of furnishing and insuring a product—is it not your judgment that that in itself would have a stabilizing effect upon the market, at least, and prevent to a certain extent the soaring of prices, a greatly increased price to the farmer? That is to say, it would hold the price down; have a tendency to hold it down over the country and prevent undue control by any limited numbers of dealers or producers. The fact that the Government was in the market with its products ought to have at least a stabilizing effect, if it did not have the effect ultimately of reducing the cost to the farmer. Is it not your judgment that that might happen——

Mr. WASHBURN (interposing). It would have——

Senator KENDRICK (interposing). To an extent, I will say, beyond this 1 per cent, or any limited amounts?

Mr. WASHBURN. It is not clear to me how it could have any effect beyond the sulphate of ammonia, but it is readily conceivable that it would hold the sulphate of ammonia down.

Senator KENDRICK. I will illustrate my point by an explanation by what, as I understand it, has happened in the cottonseed oil of the country. I have been informed that those mills have passed largely under the control of just a few men. It is a product that has proved enormously essential in the live-stock industry and the production of meat products and in dairying not only in our own country but in foreign countries. And there seems to be no limit to the price asked and the price demanded for that product. It is not limited to a reasonable profit for the manufacturers, as I understand it; it is only limited to what the profit will bear and dispose of the product. So if there was some steadying agency in the market that would not intend to levy the highest possible tax upon the consumer, it is quite conceivable, as it appears to me, that that would have a tendency to hold it all down. Do you understand the question?

Mr. WASHBURN. I understand your question, and I want to be entirely responsive. I think I am in saying that, in my judgment, the price at which the Government would furnish ammonium sulphate would have no effect upon the other materials than the ammonium sulphate in the market. If the Government should undertake to manufacture ammonium sulphate and dispose of it at extraordinarily low prices, why, unquestionably, it would have a disturbing effect upon the nitrate of soda, and I do not know how much effect it would have upon organics, because you have just touched upon a matter that is a surprise to all of us, and that is the insistence that the farmers and fertilizer manufacturers have for using organics, irrespective of the prices, because they have always been away up above nitrate of soda prices. They occupy a field of their own. I have never heard before that control of them could be ascribed to it, because there is a very wide field of those organics. With the exception of cottonseed meal and tankage the production of those raw materials of organics comes from many sources and through small dealers.

Senator KENDRICK. Senator Ransdell has a very much more intimate knowledge of this cottonseed cake business than I do, perhaps, in one way. He knows better as to the question of control and ownership of mills. But I have the kind of experience that comes from having to buy the products, and it has been my impression, based upon apparently reliable information, that there is a real monopoly in the ownership of the cottonseed mills, cottonseed oil and cake mills.

Senator RANSDELL. I could not give you any reliable information on that, Senator; I have heard a good deal of the same kind of talk; I do not know; I have never had occasion to investigate. Of course, I live right down in the heart of the industry.

Senator KENDRICK. The reports came last fall, in connection with the product, by those who sold, dispensed it, in advertising their products to their patrons, the statement was made openly that "we are not particularly concerned about any domestic business. There is enough foreign demand to consume the entire supply." But there was apparently no regard for the domestic consumer. It was only a matter of taking the highest obtainable price, and my question now related to that particular point. If the Government were producing a commodity here that is just as essential as that is, and they were concerned about supplying the domestic needs of the country, is it not quite possible, and highly probable, that they would have a steadying effect upon the price of the product?

Mr. WASHBURN. We find here the answer, in just what the condition is to-day, and what it always has been. Those materials that you refer to are selling as high as $8 a unit for ammonia.

Senator KENDRICK. The price of cottonseed cake the six months last past has been, as I recall it, $80 to $84 a ton, to be used for feed for live stock.

Senator RANSDELL. Where, Senator?

Senator KENDRICK. In the Northwest and all over the western country; in fact, as far south as the State of Texas.

Mr. WASHBURN. Mr. Prankie, what is the nitrogen content of cottonseed cake?

Mr. PRANKIE. Seven and a half to eight and a half per cent ammonia.

Mr. WASHBURN. Let us take the average of 8 per cent ammonia content; that would be, then, measured in terms of ammonia, $10 a unit that you pay.

Now, here, it seems to me, while it may not be the answer—because it is hard to answer this kind of question, but where you are paying $10 a unit for ammonia in cotton seed, the price made by the by-product coke-oven industry in this country for sulphate of ammonia is $3.50 a unit, one-third. Now, with sulphate of ammonia already a third of the ammonia in cotton seed, and evidently not influencing it, what would you pay for it when the Government comes along and reduces the price 20 or 25 per cent on sulphate? It does not change the relationship any.

Senator KENDRICK. I would consider a disastrously low price just as costly to the people of the country as one that was disastrously high. I will answer your question like that. But it might develop that one situation in regard to the price would be entirely in the interest of a few producers, and the price, on the other hand, entirely in the interest of the common good. For instance, in this cottonseed cake, as we come back to that, because it is a recent experience—now, if the Government had been producing in proportion any great proportion of that quantity, they would have had an interest in supplying the domestic needs where the other people, the individual, without competition, we will say, were concerned only about getting the greatest price for it. Now, my question, as I intended to direct it, was as to the possible beneficial effects of a Government development here upon the common good of the country, of furnishing an absolutely essential product at a reasonable price all the time. We have this experience that emphasizes this particular situation: We had an empire of the country drouth stricken, and we were compelled to resort to every possible means to carry our live stock through the winter, and I dare say that many of the flocks and herds of the West have been saved at a cost aggregating their real value during the past winter; and these people who had control of this national product—it is not perhaps produced anywhere else on earth, as far as I know, except in the United States. Do you happen to know, Senator?

Senator RANSDELL. I do not know; I suppose they make it in India and Egypt, where they raise cotton.

Senator KENDRICK. And the people who control the supply with something like definite control as to the price, as I understand it, were not interested at all, or at least apparently not from their published statement, as to whether those of us in the country were supplied or not. They were concerned only about the best obtainable price for their product.

Senator RANSDELL. Since you are speaking of cotton seed as a product, do not you think you ought to carry your program a little further and invite the Government to go into the cattle business, in order to regulate the price of feed to the consumer? You want to get the Government into this business of making nitrates in order to regulate the price to you as a cattle feeder. Now, logically, I think you ought to carry it a little further.

Senator KENDRICK. The two things are not analogous, Senator. I asked the witness—he had pointed out to us that the extreme limit, as I understand it, that the Government would probably reduce the cost to us was 1 per cent; the cost to the farmer would be 1 per cent lower. Is that right, Mr. Washburn?

Mr. WASHBURN. Yes; assuming that he could get the entire saving.

Senator KENDRICK. Now, the question I asked was if he did not think that the fact that the Government was involved in the production of this very essential commodity would of itself have a stabilizing influence and prevent a monopolistic control of the product?

Senator RANSDELL. I understand your question, and I think that the Government getting into all of these enterprises would perhaps have a stabilizing effect and prevent a monopoly; but none of us want to see the Government go into any kind of business that the individual can do just as well. This is a peculiar situation at Muscle Shoals, as I understand it, and I have thought that we ought to go ahead and do what we can with the enormous expenditure that we have made there; but if individuals can go and do the work just as well as the Government I would prefer that they do it.

Mr. **Washburn**. And if I may just crystallize my answer, I would say that I would not know of any way—I would not believe there would be any way by which the Government manufacture and sale of sulphate of ammonia could have any effect upon the price of cottonseed meal or similar articles. As to the probable reasonableness of that belief, I would point to the fact that sulphate of ammonia has always sold per pound of nitrogen, which is the way of judging it, very much cheaper than cottonseed meal; and to-day, on the example that you furnished yourself, sulphate of ammonia is selling for substantially a third of what cottonseed meal indicates.

Senator **Kendrick**. That indicates, Mr. Washburn, that there is a supply in excess of the demand, for those particular——

Mr. **Washburn** (interposing). Of sulphate?

Senator **Kendrick**. Yes.

Mr. **Washburn**. That is one of the possible conclusions. There is a capacity for supplying that is very much in excess, and there is an ample quantity to take care of the fertilizer that it is possible to produce at this time.

One of my associates just handed me a note here, calling attention to the question of Government regulation of coal prices and the stabilization of the prices of articles of manufacture. Of course, we all know where the cost of articles has gone since the stabilization of coal prices, and coal constitutes, as an average, somewhere in the neighborhood of 7 per cent of the cost of producing those articles; so that while the Government held coal down the price of the articles went on soaring, regardless of that control.

Senator **Kendrick**. I think it might be safely said, Mr. Washburn, and probably would be strongly supported by the average consumer of coal, that the Government failed to hold the price down.

Mr. **Washburn**. Well, I just gave you an example for your consideration.

Senator **Ransdell**. Perhaps it is hardly fair to speak of what we have in war time, but when we saw the Government take charge of the railroads we also saw an enormous increase in the cost of transportation in every way. The Government seemed to do things in a more expensive manner, usually, than corporations or individuals do.

Mr. **Washburn**. Let us take the view that by some means the farmer secured a saving of fully 1 per cent upon the price he pays for his fertilizer. East of the Mississippi River, which is the only section in the United States in which fertilizer is used in any quantities worth considering, where normally before the war the average expenditure per farm for fertilizer was $40, there would be a saving of 40 cents per farm.

Let us take still another view as to the importance of this situation which the Government wishes to occupy as a merchant and manufacturer. As already stated, the importance of ammonia nitrogen in the fertilizer industry is less than 10 per cent; 10 per cent of the $40 per farm is $4, and, therefore, what the Government is really doing is injecting itself as a manufacturer and vendor of a raw material which, even after it is manufactured and delivered to the farmer, represents an expenditure on his part of only $4 per year. You see it is of infinitely less importance to the farmer than his wagon, his pants, or his shoes. I know of no reason, if it is a proper thing for the Government to enter the field of trade and manufacturing, why it should not experiment with something which is really worth while and take over the wagon works, the pants factories, or the shoe shops and supply the farmers by those well-known Government methods which produce so cheaply and distribute so satisfactorily.

The truth is, gentlemen, that the farmers of this country will be benefited not one penny's worth, even if the Government plant could produce and sell the material as its champions claim for it.

After all, we are dealing here with a question that involves an expenditure of $4 per year per farmer, and if that were a reason for the Government going into this industry, nationalizing this industry, why it certainly ought to take up something worth while. Four dollars a year on the farm is a small matter compared with wagons and shoes and hats, and I should think that if the Government would treat the thing logically that it had better give its attention right now to the nationalization of the wagon industry, and the hat and shoes, and most particularly the shoes.

Senator KENDRICK. I have no sympathy with Government ownership. I want to make that clear. But here we have a great plant; that it is evident from testimony that it is necessary to keep it conserved, either through operation or through care, and it will require diligent attention to conserve without operation. It would seem necessary to use it to the very best economical advantage.

Mr. WASHBURN. Senator, I would like to disabuse your mind of the idea, and the committee, of course, that that plant must be used in order to preserve it. It is the first time in the history of chemical industry that I am familiar with that it has been advanced as a way to preserve a chemical plant is to use it, and I think that is not the only unique situation reflected in the claim of the administration, but in every estimate of cost that they have made, because one of the things the administration thinks it might manufacture, is nitrate of ammonia. It is down there in a report by Mr. Glasgow; but in the cost of production of that, there is no depreciation on what we call the wet plant, or the dry plant either, for that matter, but there are parts of that plant—and we built it and designed it and know about it—we are using the same things, only in a smaller capacity, elsewhere, that in use absolutely wears out in two years and are entirely gone. That is one of the most expensive features in it; that is the aluminum, and the whole nitrous fume-cooling apparatus; used up and worn out; eaten up in two years; and yet we are told that the way to preserve that plant is to eat it up, and while they are eating it up they do not charge the cost of eating it up in their estimate. I will come to other costs in a moment.

Now, as to the dry plant, to say that it is necessary to run that to preserve it we know that is not the case. We have been using that apparatus for years, using it all the time, but it requires intelligent care. You can not just simply shut up all of the doors and windows in the building and allow the temperatures on the outside and those on the inside to bear absolutely no relationship to each other, so that you have condensation on the inside of it. There are all kinds of tricks and methods in that connection, and a certain amount of apparatus has to be cared for in a building where the temperature can be preserved artificially. But, practically speaking, the way to preserve that plant is to take care of it in idleness, and it is there and will be in perfect running order if taken care of that way, ready for the Government to use it when they need it for explosives upon the approach of war.

If we start out with the assumption that that is a plant having cost this Government millions of dollars, and as long as we could use it and return to the Government the cost of the labor and materials entering into the product, and they had no interest at all upon the investment that was made to date, it would be the simple aspect in which this thing has been presented to you. Even that simple aspect does not exist, for there are a great many things that apply to that aspect which rob it of its simplicity. In addition to that—and I am more anxious than on any other point to cover this situation—the Government has not even got a plant there that it can operate at the cost for raw materials and labor and superintendence and interest on the necessary new investment for that particular plant. It has not got that kind of a situation; and if it has not, your plant fails in the first requisite of any plant, to show more money in your pocket at the end of the year than you had in the beginning. There is going to be less in your pocket; it is going to be a burden on the taxpayers of the country to run that plant.

Now, there are a good many other elements entering into it as well. In the matter of costs, which point I have now reached, if I understand correctly, it has been presented to the committee by the Government in the matter of anticipated cost of production, there has been a claim, I think, in the secretary's testimony that it would be so low as to enable the Government to make a profit. Now, if we take the unit prices—I mean the prices per pound or ton or yard of raw materials and labor at their present figures; that is, what things are worth in the market to-day; what you can buy them for—and that is the only fair basis of dealing with this situation at the present time, because you are going to compare cost with market prices. You can not compare costs under an anticipated state of affairs with existing prices; the two things must go together. That is the only fair basis for making a comparison, with present market prices of the compared material, and charging depreciation and interest only on necessary new expenditure to be made by the Government, there would be practically no net profit resulting to the Government between its costs, as we estimate them, and the present market price of the sulphate of ammonia. Broadly speaking, the present cost to the Government without interest or depreciation on any part of its expenditures to date, would be as great as the present market prices; and the present market prices of that material are less with relation to normal peace-time prices than upon most articles of trade; four and one-half as compared with three and a quarter.

I think it is fair for the committee to assume in this matter that the organization which I represent has better knowledge of the costs than the gentlemen connected with the Government can possibly have, and this is no reflection upon the capacity of these gentlemen, but they are without experience, and therefore without knowledge upon many of the pertinent steps, and have to rely upon hearsay or published information, or some sort of short-time record, which may not be applicable to the situation. We have been for years engaged in making just such estimates as have been made here, and are continually testing them in the production and marketing of millions of dollars of products—it is the daily thing we are doing, nothing new to us. It is not the engineer's job. Nearly all of these estimates that we have here are on the basis of your engineers' records; so many pounds of this to make so much product. While we will agree with almost everything they have put down in this respect, it does not alter the thing; these are the things the engineer does not know; the things that the works chemist does not deal with, at least until he becomes a managing chemist or something of that kind.

(Whereupon, at 3.15 o'clock p. m., the committee adjourned to meet at 10 o'clock a. m. to-morrow, April 10.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

SATURDAY, APRIL 10, 1920.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met, pursuant to adjournment, in room 326, Senate Office Building, at 10 o'clock a. m., Senator Asle J. Gronna presiding.

Present: Senators Gronna, Kenyon, Wadsworth, McNary, and Kendrick.

The CHAIRMAN. You may proceed, Mr. Washburn.

STATEMENT OF MR. FRANK S. WASHBURN—Resumed.

Mr. WASHBURN. When we adjourned yesterday we had just reached this matter of costs of the product, and those costs, of course, have a bearing on the profits; and I have to present two thoughts on this matter of costs: One is on the basis of accepting the costs that the administration has presented. They state on page 92 of the report of the hearing that when the water power shall be placed in operation there will be annually a profit of $2,900,000.

Now, what kind of profit is that? Absolutely net profit? Does anything come off at all? Let us see.

To begin with the Government has got to pay interest on the new money that it puts in there. There is not a cent of interest figured into costs; and the new money that it puts in there is $38,000,000, and 5 per cent on $38,000,000 is $1,900,000 that this Government has got to pay ou in gold in order to run this plant, and it has got to come out of that $2,900,000. There is not any other place for it to come from.

Senator KENYON. Do they not include that at all?

Mr. WASHBURN. No; they do not; and therefore that reduces to a million——

Senator WADSWORTH. Just a moment. By the $38,000,000 you have just referred to you mean that portion of the cost which they are to use——

Mr. WASHBURN (interposing). That is the additional amount of money that they are asking for, or are proposing to invest, and is covered by $25,000,000 in the water-power plant and $12,500,000 that they are asking for here, and $500,000 in the high-tension line, or rather transmission line or distribution line, from the dam to the plant No. 2, with the necessary electrical equipment. There is the $38,000,000.

Senator **Kenyon**. I thought they were not asking for anything here.

The **Chairman**. The bill provides for an appropriation of $12,500,000, but the Secretary of War suggested that they might sell 150,000 tons of nitrates on hand, which would bring approximately that amount.

Mr. **Washburn**. Off of that $1,000,000 is there anything else to come? Most certainly they must take off of that all sorts of depreciation in operating an acid plant, and to make sulphate of ammonia they require an acid plant. Let us take our own figures of depreciation. We are very large manufacturers of sulphuric acid and were very large manufacturers of sulphate until we could not keep in the market any longer, and when we take out the depreciation that is not figured by the Government on that sulphate plant which is in the $12,500,000 appropriation that is asked for, and take out in addition other costs in connection with water power that they have not included, for they have only included something between $4 and $5 a year for water power as total cost—taking that out, comes pretty nearly wiping out the remaining $1,000,000.

It gives the right color to it, and it is substantially correct within a few dollars. And the fact is that it is now proposed that this Government shall spend $38,000,000 or invest $38,000,000, and then run a plant on which there will be no net return over and above the cost of operating, accepting the Government's own figures for the cost of operating.

I am not quarreling now, as to the costs, but I am accepting their costs of sulphates and all that sort of thing. But they have forgotten, or for some reason or other have left out things that Uncle Sam has got to pay out that $2,900,000, and those things amount to somewhere between two and a half million and three million dollars.

The **Chairman**. I think it is only fair to Mr. Roberts, who I think made those calculations—if I am mistaken about that Col. Burns will correct me—that he stated specifically that interest charges were not taken into consideration, and I take it that taxes would not be taken into consideration. So that I presume there is no disagreement between you and Mr. Roberts about that, Mr. Washburn?

Mr. **Washburn**. No; I am trying to quote him accurately.

The **Chairman**. Yes; I believe you are quoting him accurately, as I understand it.

Mr. **Washburn**. Yes; but here is the distinction in thought and in importance. That part of the plant which is there and was built by capital out of the pocket of Uncle Sam, crystallized into bricks and mortar and concrete and machinery, and one might say of that: "Well, the interest runs against it whether we use it or not," and therefore from certain aspects that one wishes to view the matter, one of them might be, "Well, we will forego interest on that; we will not figure interest on that which the Government has already expended against our cost of production." What the Government has done is that it has not figured interest against its present investment; and that is not the point I am speaking of. I accept that as a Government method.

But, then, the Government says $2,900,000 of profit; that is the big figure outstanding—run the plant and get $2,900,000 profit.

But what has Uncle Sam got to pay for that profit? He has got to pay 5 per cent on $38,000,000 not yet expended.

The CHAIRMAN. New capital?

Mr. WASHBURN. New capital. I suppose there is some small amount expended upon the foundation of the new dam, but it can not be very large; it is only in the preparation of that foundation. Substantially there is $38,000,000 still to be spent, and the interest on which has got to be paid by the taxpayer, and there is no way of getting it out of this situation. The Government tells you in its own testimony, except that it is lost to Uncle Sam, and it must come out of the $2,900,000. And out of the money remaining, after deducting 5 per cent of the $38,000,000 must come the items of depreciation and items of cost of water power that are not included in the Government estimates here.

The CHAIRMAN. Of course, that is very important, Mr. Washburn, but if you take the statement which you have just now made in connection with the importance of getting cheaper fertilizer, if it were possible to do what some people seem to believe it is possible to do, we might overlook that. However, according to your statement, Mr. Washburn, if I understand you correctly, this, you said yesterday, represents the fertilizer, what goes into it [referring to glass container on committee table], and we will divide it into 10 equal parts, and there is not to exceed one-tenth of it that would be affected, so far as ingredients used in fertilizer is concerned, by the manufacture of this product at Muscle Shoals. Did I understand you correctly?

Mr. WASHBURN. That is correct. There is only about one-tenth of the materials used in fertilizer that it is proposed to manufacture in part at Muscle Shoals.

And yet they call the plant "a fertilizer plant." It is not a fertilizer plant; it is an explosive plant, to which it is proposed by the addition of $38,000,000 to transform into a plant which can make sulphate of ammonia, and sulphate of ammonia is only 10 per cent of the materials, in value, that enter into fertilizers in this country every year.

There is an interesting side light to that situation which may explain in a way what developed here is to be an agreement on the part of the administration with the point of view I am presenting to you gentlemen on this matter, because in the testimony of the Government there is this statement by Mr. Roberts in testifying here, and Mr. Roberts is the gentleman who has been recommended in the report of Mr. Glasgow, the nitrate director, which report I believe is also in your record—if it is not, it is in the record of the Graham committee—but, in any event, the nitrate director, whose mantle has fallen onto Mr. Roberts, and whom he recommends to be president of this new corporation, states in this testimony—I can not cite it here, because we got it out of the galley proof that you gave us [reading]:

> From Mr. Glasgow, in his letter of October 22, 1919, to the Secretary of War, showing that the profit from the operation of plant No. 2 with steam power is not great enough to be attractive for either the Government operation or private industry.

Then he goes on to argue for the necessity of using water power. Now, let us see for a moment: The administration itself appears here and says, in effect, regarding operation by steam power. "It is neither attractive for Government operation nor for private enterprise, because the profits are not sufficient."

Now, when I take the profits that they expect to make by steam power, which are about $900,000 according to their way of figuring; and when I take the profits that they figure on water power it is $2,900,000, a difference of $2,000,000.

Therefore, if out of that figure of $2,000,000 there come things that they have omitted and forgotten, and which reduces the profits on water power to the profits that they assume for steam power, which are unattractive to everybody, then the plant operated by water power is unattractive both for the Government and for private interests. And that is just what happens. With steam power there is $900,000 profit; with water power $2,900,000, a difference of $2,000,000. But out of that $2,000,000 must come, certainly, interest on your $38,000,000 at 5 per cent. That is substantially $2,000,000, and therefore there is no more profit in the operation of this plant by water power than by steam power; and to repeat, they advise you here in their testimony that it is unattractive for governmental operation or for private industry on that basis.

I want to make clear now that I am not quarreling with their cost figures in this analysis, but I am merely taking their own figures and accepting them; and all that you gentlemen have to believe or disbelieve about it is whether it is going to be necessary to pay interest on $38,000,000. That is the only thing that is involved in it.

In the matter of this construction of water power now that our minds are turned to water power for the moment, there is another objection and a more serious one than the question of profit or no profit, and that is that, substantially speaking, about all the cost of water power is the interest and obsolescence and depreciation on your costs and your equipment and structures; and therefore every wise business man who is engaged in the development of power and their stability will only construct at times when it can be built cheapest.

Here is a very striking thing in this situation and to me one of the most striking, in comparing the steam-power plant which is in existence there ready to go to work and the water-power plant which it is proposed to build, and it is this:

That when we figure comparative costs of steam power to-day with water power down there, we take coal at the price of $4.65 a ton—now, it is in there and you must pay your interest anyway on your steam plant—and 75 per cent of the cost of operating that steam plant, additional, over and above what the Government is bound to pay anyway, is in your coal. Coal is not going to stay at $4.65. During the time I was president of the Alabama Power Co., I bought for our big power station in this same district, coal, delivered at $1.70 a ton, excellent coal, as we had to have good coal under our boilers. Our steam plant operated as a relay for the hydroelectric plant down there. Some coal came from the mines I am interested in—and at that time I was president of the coal company. We furnished coal down in that section from Kentucky at $2.15 to $2.20.

In connection with the coal industry that was outlined for development at the time this war came on, coal was figured as being capable of delivery at Muscle Shoals at something like $1.85.

Here we have got a steam plant, and we are figuring the cost of the power at that steam plant at a time when 75 per cent of that cost is in fuel, with its very top-notch price. Steam power can be reduced in cost as the price of coal goes down, and very materially because the coal is a big item.

But the Government proposes to build and put that steam power out of use, or to duplicate it with a water-power plant and build it at a time when 80 to 90 per cent of the cost of the energy developed by that water-power plant is in the interest and depreciation and other items depending upon cost, at a time when costs are away above anything we have ever known before.

For instance, when this Muscle Shoals project was fathered by me and I urged that a plant be built upon it—an industrial situation that then commended itself—the furnaces just north of the Tennessee River within 30 miles of this very place, operated by a company which was owned by my family connections and a company of which I am a director and have been for years, was paying 60 cents a day for common labor around the furnaces. Those wages eventually went up to $1 at the furnaces. Common labor around in that section at Muscle Shoals was $1.25 a day. The testimony given by the engineer officer of the Engineer Corps, Col. Lytle Brown, a few days ago, before the Graham committee, stated that he is paying for common labor 40 cents an hour. Therefore, for eight hours' work he is paying $3.20, as compared with $1 for eight hours under normal conditions that formerly prevailed in that country.

That is not the worst feature of it, and is not the whole story by any means. His turnover there at the present time is 50 per cent a month. He loses, in other words, 50 per cent of his laborers, of the whole outfit, each month.

Senator **Kendrick**. He can easily understand how it would be wise to defer or postpone for a short time the construction of this power plant. But as we have it and have been told by conservationists that there is a real limit to our fuel supply, and that it is a good plan to conserve it, in event that this plant would be permanent, once it was established, would it not be in the interest of good judgment to substitute the one for the other at an early date, or as soon as it could be done at normal cost?

Mr. **Washburn**. When it can be foreseen that the water-power plant will be needed or can be used, we will say, for the operation of industry or industries or this nitrate plant, and costs of building it are normal or approaching the normal, then is the time to build the water-power plant. The serious feature about building that water-power plant to-day is that you are ruining forever the prospect of that district being a great industrial center, because you are fixing upon it something over $20 a horsepower per year instead of possibly something as low as $5 or $6 or $7; and when it is once crystallized there in money, you can not get away from it. It lasts right down through the ages, and, to my mind, it is not much less than a crime against that community down there to put it in a position where that power, unless the country is going to subscribe out of its pocket a loss on the use of that power, to fix for all time an excessive cost for that energy. The time will come, in all probability, and to that end I have something to suggest before I get through that is constructive, when this Muscle Shoals plant or parts of it, at least, shall be used and when the water-power plant shall come along and be constructed as one factor in the development. But to do it to-day is destroying the prospects for the future; and out of it all no one will get anything out of it, as I have shown.

Senator KENDRICK. How soon, may I ask, does the Government propose to begin construction of the power plant?

Mr. WASHBURN. They have begun, and I do not know how far along they are, but the last time I saw it and the last time I had word of it they were working in the stream putting in caissons for exposing the foundations. I do not know how far along they are.

Senator KENDRICK. You do not expect, Mr. Washburn, that the wages will ever return to a dollar a day or 60 cents a day?

Mr. WASHBURN. Oh, absolutely not. But labor will become a lower price than at present, and materials will be lower, interest will be less than it is at the present time. Money can be had cheaper and labor will be more controllable and more efficient. Labor is so well employed and so prosperous, from the standpoint of the immediate present, that all kinds of inducements have to be made even to the point of submitting to a degree of idleness that in normal times would not be permitted. We know that labor is universally inefficient, and a great many of us who are not laborers are inefficient. The people of Europe right straight through are inefficient. It is perfectly astonishing to find over there that nearly all classes of people are not disposed to go out and give that fervor and energy and pressure and attention to their work which they formerly did.

The CHAIRMAN. If it were possible to get water power at $7 per annum at Muscle Shoals, at how low a price would you have to buy coal in order to compete with it in producing power?

Mr. WASHBURN. I can not answer that; it takes calculation. But I will give you an answer and send it in.

The CHAIRMAN. I wish you would, in order that the committee might have it.

(The data referred to was subsequently prepared and furnished by Mr. Washburn, and is here printed in full, as follows:)

COST OF STEAM POWER AT MUSCLE SHOALS PLANT.

[60,000 kilowatts equals 80,000 horsepower.]

Assume steam plant exists as is and that depreciation and interest will amount to essentially the same thing whether the plant is operated or not, inasmuch as maintenance and supplies will keep the plant in first-class operating condition. Under these circumstances the actual cost of power when the plant is operated over and above the cost of carrying the power plant in idle condition, will be as follows:

Coal, 394,000 tons, at $0.863	$340,000.00	
Administration and labor	120,000.00	
Maintenance and supplies	100,000.00	
Total	560,000.00	
Cost per kilowatt-year, excluding fixed charges		$9.35
Cost per horsepower-year, excluding fixed charges		7.00
Cost per kilowatt-hour, excluding fixed charges		.00165

From this it will be noted that cost of coal can not exceed $0.863 per short ton to produce power at $7 per horsepower-year, excluding fixed charges.

This power plant cost $9,946,000. If one charges interest at 4½ per cent and a flat depreciation and obsolescence charge of 5 per cent on this capital, the total of the fixed charges will amount to about $900,000, or considerably more than $7 per horsepower year. Therefore, this plant could not produce power at $7 per horsepower-year at any, or, in fact, no price for coal and carry its operating and fixed charges.

Senator KENYON. Mr. Washburn, what puzzles me in listening to your testimony, which is interesting, is why you have turned against this whole proposition. Is it because you think it is a useless and wasteful thing? You were very enthusiastically for it when some of us were fighting it.

Mr. WASHBURN. Senator, I have not turned against anything that I stood for in the past. This is a new situation and a new thing, and the results upon which one bases his judgment in matters of this kind are the outcome of taking the factors that are in front of you, the conditions that apply, and analyzing them; and there are a vast part of them which are technical, commercial, financial, and industrial, all four of them—and applying to those various considerations calculations which eventually show a difference between cost on the one hand and income on the other. And then you analyze it to see whether there is profit left.

Senator KENYON. Is your position based at all on what effect it might have on your company?

Mr. WASHBURN. Not in the least. The analysis of this situation is based purely upon the contemporaneous conditions and those which we can look forward to now as distinguished from the conditions which existed in the past when we were talking about an entirely different proposition, and what it was readily expected then the future would hold.

This war has upset the whole world. When you get over in Europe you find Europe just closed down; it can not move, from the effect of this war. We are restricted here in this country to a much greater extent than we imagine because we do not feel it in our daily life until we get to outlining future activities and the effect on profit from our investments and assets.

A very striking thing has happened as compared with the old days, or the days comparatively a short time ago, is that the world now has an enormous surplus productive capacity of ammonia nitrogen, a thing that would be manufactured down there and that is a by-product which is going to be produced regardless of whether they sell it at one price or another. It has got to be produced, and so the market demand and the market supply, which are the two big things that always challenge the promoter of any industry, are totally different from what they were in the past.

In the matter of the costs of the product itself, something which I think it will be granted we ought to know about, for that is the thing we make and have been making; sudying costs, not only figuring them but getting the proof of our figures every day in our plants. We do not agree with the Government in the matter of costs; and the nature of the disagreement in costs is not those things that the engineer observes or those things that the members of the Government inspection corps at Muscle Shoals could observe going on—we do not disagree as to that portion. For instance, I notice here in one case the ammonia gas, where the Government puts in almost exactly the same number of tons of raw material, lime nitrogen, as we do; and they put in exactly the same amount of soda ash; they put in exactly the same amount of steam. Then even put in more power than we do in the manufacture of ammonia gas.

So the difference between the Government figures and our figures is not serious nor controlling as to the amount of product, of power, of raw materials, etc., required in the processes. That is something that it is possible to observe. We have given the gentlemen figures as to what they are; and they have observed at Muscle Shoals what certain things are, but it comes in the nature of things they can not know anything about, many other items. When we build costs we have working examples in essentially exactly the same process, because we duplicate the thing absolutely. We use just the same raw materials, we use just the same furnaces, the same electrical equipment, the same liquid air equipment, the same acid equipment and the same sulphate equipment, right straight through, and when we get through figuring we find that our costs are very much in excess of the Government costs, and so much in excess that they would wipe out this $2,900,000 of profit, even if we did not charge any interest that the Government had to pay on this $38,000,000.

The CHAIRMAN. Does that statement apply to other products besides the nitrate?

Mr. WASHBURN. The sulphate?

The CHAIRMAN. Yes, sulphate.

Mr. WASHBURN. It applies to all of the products that the Government figures on.

The CHAIRMAN. You will find on page 88 of the record, Table 1, giving estimated cost at the mines of producing available phosphoric acid by treating high grade phosphate rock with sulphuric acid. And Table 2, where the electric furnace is employed.

Mr. WASHBURN. Phosphoric acid is something that does not enter into this situation, Mr. Chairman, and it is not proposed to manufacture that down there.

The CHAIRMAN. But it enters into the fertilizer question?

Mr. WASHBURN. Yes, it does enter into the fertilizer question. Now, I have made no comparison between those figures and our figures on phosphoric acid, so that I can not answer. I have only taken those things which the Government testified here that they want to manufacture and are involved in this so-called profit of $2,900,000.

The CHAIRMAN. Maybe I misunderstood you yesterday, Mr. Washburn. I understood you to say that we are manufacturing now more of the sulphate of ammonia than we can use, that is, this 9 per cent chemical that you speak of or, including the cyanamid, say 10 per cent, and that we are getting this from the coke ovens in the manufacture of coke for the steel industry; that in normal times there is an oversupply of that particular product.

Mr. WASHBURN. The capacity for producing that product is greater than the demand for it, and the production is very much in excess of the domestic demand in the United States, and it has been relieved by export from this country which has been carried on up to the present time for a number of months quite extensively. That continued exportation for any great length of time is not likely; and even if it were, I imagine the Government would not want to go into the manufacture of material which was to take the place of a similar material exported out of the country, for that essentially puts the

Government into the business of exporting; that would be the economic effect of it. But the whole world excess capacity for producing sulphate of ammonia is so enormous compared with the demand that just as soon as Germany can get to work and England and France, the studies of the capacities of those plants over there and the demands and all that sort of thing indicates, as I showed you yesterday on one of the curves indicate a perfectly enormous surplus. That is the conspicuous thing to everybody in the ammonia industry.

Senator WADSWORTH. Do you intend, Mr. Washburn, to point out those elements of costs which the Government has omitted and which you say in your industry you constantly encounter?

Mr. WASHBURN. I will give the nature of some of them. Our figures here are the intimate commercial figures of a secret process, and I hesitate to make them public, but we find that the cost of sulphate would be about $87 a ton, without any interest on anything that the Government has built up to the present time; and the present market, as I told you yesterday, was $4.50 a hundred, which is $90 a ton, which would practically break even on cost.

Senator WADSWORTH. What is the Government figure of costs per ton? Perhaps I have it on page 92 of the hearings—$48.20?

Mr. WASHBURN. Yes.

Senator WADSWORTH. Is that the corresponding figure; am I right on that?

Mr. WASHBURN. Yes; it is the corresponding figure.

Senator WADSWORTH. Then the figure $65 per ton, which is under the heading "Per ton sale," is what they expect to get for it?

Mr. WASHBURN. What they expect to get for it, and part of that difference is due to the different assumptions on the costs of raw materials, such things as limestone, coke, and coal. We have taken the prevailing costs.

One of the noticeable items that their estimates are defective in is the repairs, renewal materials, and labor. Of course, in a brand-new plant for a period that is not very heavy; but as soon as it comes down to normal it becomes a very large and important item.

There is another item that my attention has just been called to, and that is they assume to reduce royalty in their estimates. They assume that the American Cyanamid Co. is not to be paid the royalty that has been fixed, but that it will be lowered by arbitration. But that difference on the sulphate, as between the figure here of substantially $50 and our figure of substantially $90 epitomizes the whole situation, so far as the costs are concerned, and there is nothing entered into our costs here except what is the outgrowth of our experience and knowledge of the art in the daily practice of it.

Senator WADSWORTH. Do you mind saying what you are getting now per ton on the market?

Mr. WASHBURN. For cyanamid fertilizer, which contains the same amount of nitrogen as sulphate of ammonia exactly, we are getting $87.50 to $100 a ton.

We gave up the manufacture of sulphate of ammonia, which we did manufacture on a very large scale, which is this same material that it is proposed to manufacture down there, having abandoned its manufacture because we could not produce it and stay in the market at the figures per ton in excess of $100 a ton. Is that responsive to your question?

Senator WADSWORTH. Then, you would deduce from that that the Government could not stay in the market, except at a loss, at the figure of $65 a ton?

Mr. WASHBURN. Yes; that is the direct deduction; and, however many ways we analyzed this, however we took this thing and worked it through, at every standpoint we find that that is the unavoidable conclusion, that it will cost the Government as much or more than it will receive for the product, and while it is figuring on receiving $65 for the product the product will cost it $87.

Senator WADSWORTH. Exclusively of interest on the additional investment which the Government, you say, would make?

Mr. WASHBURN. The Government's $65 is without any interest on the moneys still to be invested and without any interest on any moneys already invested.

Senator WADSWORTH. The Government's figures of costs and your figures of costs for the same material are so tremendously apart that I wish there could be some more detailed explanation of that. Somebody must be terribly wrong, either the Government or you?

Mr. WASHBURN. Yes. One of the difficulties in presenting that is that we have not had sufficient time, after knowing what the Government figures are, to analyze them and make a tabular statement. We have analyzed them and have gotten a comparison and a correct one, but it is not easy to follow it through and display it.

The CHAIRMAN. Mr. Washburn, I think that question asked by Senator Wadsworth is a very important one. Would you be willing to send the committee a statement making comparisons with the Government's figures, the way they figure it; that is, without interest; and then make another comparative statement, figuring the interest, so that we may include that in the record?

Mr. WASHBURN. Would it be practicable, Mr. Chairman, for us to send you two things—the estimate that we would be willing to have made public and go into the record, and another estimate which ought not to go into the record, because we would be disclosing the whole art.

The CHAIRMAN. I did not intend to ask you to send the committee anything which you do not care to publish, but just those things which you do publish and which you have no objection to having published. Of course, I would not ask that you give away any of your secret processes or any of your formulas, or anything of that sort, in figuring costs; but such things as you and your company care to make public is what we desire. It might be helpful in making the comparison with the figures presented by the Government.

Mr. WASHBURN. Mr. Chairman, we will send you everything that we can without disclosing facts which would be a menace if known. I will do that.

Mr. Chairman, would it be satisfactory to disclose totals without disclosing the details?

The CHAIRMAN. Oh, I should think so.

Mr. WASHBURN. I think I had better give you that in the form of a table rather than take your time and stretch the exercise of your memories by giving those comparisons at this time. I have got them here, but I think that would be the best way.

The Government has submitted estimates of cost, itemized and tabulated, beginning on page 95 of the report of hearing before your committee, Senate bill 3390. These estimates are insufficient, in our judgment, to cover costs of production at Muscle Shoals. They are of necessity estimates projected in a field unknown and unfamiliar to those who made the estimates, while our statements of costs are the results of years of experience, weighted to meet contemporaneous conditions as to local costs, labor, and materials, etc. If we should give an independent detailed statement of cost, a comparison would have to be instituted between the items of this statement and the Government items, which are not comparable, and therefore would not be as illuminating to the layman in showing wherein the Government estimates are deficient as for us to take the Government detailed estimate, accepting its quantities of materials and substituting for the Government hoped-for prices of materials the actual prices of those materials and accepting the Government's general items with respect to other things and adding plant general expense and replacements, which the Government has omitted. It is to be noted that we have avoided the duplication of any Government item in the addition which we make under plant general expense by excluding any partial expenses which the Government may have included and which properly fall under the head of "Plant general expense." It is to be noted also that while the Government general items referred to above are less than actual costs they are accepted in order to make clear that I am joining issue with the Government solely by substitution of material costs and adding items overlooked and unknown to the Government.

Estimate of cost of lime nitrogen, per ton, as projected by the Government with certain items which were omitted in the original, based on present prevailing unit prices.

Item.	Quantity.	Unit cost.	Total.
Limestone	1.75 tons	2.00	$3.50
Coke	0.54 tons	12.00	6.48
Coal	0.21 tons	4.65	.98
Electrodes	37.8 pounds	.07	2.65
Steam power	2,808 K. W. H.	.0039	10.92
Charcoal and diluent			.59
Caustic soda			.13
Miscellaneous materials			.86
Repair parts			1.08
Labor, operation			5.08
Labor, maintenance			2.11
Royalty, liquid air			.58
			34.96
Plant general expense			4.54
Replacements			2.50
Total cost per ton, exclusive of interest on money already expended, executive office expenses, selling expense, packing, and taxes			42.00

The manufacture of this compound was not contemplated in the plans which culminated in the erection of the Muscle Shoals Plant, and an estimate of cost from me is therefore not pertinent. I would however, call your attention to the fact that the cost of one raw material entering into the preparation of cyanamid, said raw material not being lime nitrogen, is practically double the total manufacturing cost as given by the Government experts on page 96, and indicates how seriously in error their conclusions are.

Estimate of cost of ammonia gas, per ton, as projected by the Government with certain items which were omitted in the original, based on present prevailing unit prices.

Item.	Quantity.	Unit cost.	Total.
Lime nitrogen	4.025 tons	$42.00	$169.05
Steam power	130 K. W. H.	.0039	.51
Soda, ash	0.134 tons	45.00	6.03
Steam	8 M pounds	.60	4.80
Compressed air	2.7 M cubic feet	.02	.05
Miscellaneous supplies and repair parts			.75
Labor, operation			4.06
Labor, maintenance			.70
			185.95
Add supplies, repairs, repair parts, etc., not allowed for in sufficient amount in Ordnance Department estimate			4.03
Plant general expense			2.52
Replacements			3.85
Cost per ton of ammonia gas, exclusive of interest on money already expended, executive office expenses, selling expense, packing and taxes			196.35

Here we are unable to use the Government quantities because they are too far from actual experience. This is, therefore, a complete revision (accepting the Government figures on ammonia gas, as revised by us), based on our exclusive experience in the use of lime nitrogen and ammonia in the making of sulphate of ammonia on a large scale.

Item.	Quantity.	Unit cost.	Total.
Ammonia gas	0.269 ton	$196.35	$52.82
Steam power	35 K. W. H.	.0039	.13
Sulphuric acid 60°	1 ton	10.00	10.00
Steam	1.34 M pounds	.60	.80
Labor			3.50
Repairs and renewals			3.00
Supplies			.25
			70.50
Plant general expense			1.00
Replacements			2.00
Total cost per ton, exclusive of interest on money already expended, executive office expenses, selling expense, packing, and taxes			73.50

Summary per ton of ammonium sulphate.

Total cost per ton, exclusive of interest, on money already expended, executive office expenses, selling expense, packing, and taxes	$73.50
Bags, bagging, stacking, and shipping	4.00
Total cost per ton on board cars, exclusive of interest on money already expended, executive office expenses, selling expense, and taxes	77.50
Excutive office and selling expense	4.00
Interest on $12,500 new capital to be furnished, at 5 per cent	3.00
Royalty to American Cyanamid Co. prior to June 1, 1921	2.84
Increase in royalty to American Cyanamid Co. after June 1, 1921	4.27
Grand total cost per ton of sulphate of ammonia, excluding interest on money already expended and taxes	91.61

Mr. **Washburn**. But the point is that when you check around through our own knowledge of costs—and they are not estimates of the nature that we often speak of estimates, because an estimate generally means a calculation out into the unknown; it is something that you project, in fact we speak of "projecting estimates." We are not projecting estimates here; we are telling you what the material costs. The United States Steel Corporation does not project estimates when it comes and sits down before this committee and tells it the cost of steel.

The CHAIRMAN. That was the very reason, Mr. Washburn, that I asked you to give the committee the benefit of the figures which are actual transactions, not estimates, based upon experience and commercial transactions.

Senator WADSWORTH. How long ago did you go out of the business of manufacturing sulphate?

Mr. WASHBURN. Mr. Cooper, when did we quit manufacturing sulphate?

Mr. COOPER. About a year ago.

Senator WADSWORTH. Has the contract price of sulphate gone up or down since you quit manufacturing?

Mr. WASHBURN. The market price has gone up. The market price can not be judged from the quotations that you see in trade journals; those are spot prices. For instance, the sulphate used this year about 70 per cent or 75 per cent, somewhere along there, of all that was used in agriculture, cost about $3.60 a hundred. That is not very much above its old normal peace-time price, notwithstanding all of these increased costs and war situation and all that sort of thing.

Now, this year the market has been made by the by-product coke oven industry, which is the steel and iron industry eventually, at $4.50. We sold our sulphate, however, over the market of last year, and the price that we got for sulphate was almost exactly the present market price of $4.50 per 100 pounds. And yet we could not stay in the business at $4.50 a hundred, but the Government expects to sell its sulphate at $3.25 a hundred.

Senator KENDRICK. Is your conclusion that the price advanced because of your withdrawal from the manufacture?

Mr. WASHBURN. No; because of the total quantity we did not manufacture enough to influence the market.

Senator WADSWORTH. Your competitor was the by-product coke ovens?

Mr. WASHBURN. Our competitor was the by-product coke ovens, and, to some extent, the gas works.

Senator WADSWORTH. Will they always be close competitors of the cyanamid process?

Mr. WASHBURN. Always, except on materials that we can devise and produce from cyanamid as raw material which goes into another class or constitutes another class of materials, which may be another class than in agriculture. But as long as we stay in the class of sulphate of ammonia, which cyanamid fertilizer is, our market is determined by the sulphate market, and the cyanamid fertilizer will have to sell at a less price per pound of nitrogen than the sulphate, due to the limitations which the cyanamid has.

Senator KENDRICK. Are there any other manufacturing establishments producing sulphate of ammonia than the steel industry?

Mr. WASHBURN. None, except gas works and some bone distillers, who make a few tons.

Senator KENDRICK. Well, nearly all or the greater part of the steel industry is under one control, is it not?

Mr. WASHBURN. I think the figures show that the United States Steel Corporation has about 60 per cent of the business.

Senator KENDRICK. I do not know what the figures are; I would have to ask for information about it.

Mr. WASHBURN. That is my recollection, and I might say, also, to be correct, that the gas works make sulphate.

Senator KENDRICK. This is in direct line with my question yesterday, just before we adjourned. In your judgment, is it not true that if the Government were something of a competitor in the manufacture of this product because of the incidental need of taking care of and continuing to operate this plant, that it would have some effect in holding the price of the product down that is now controlled by one industry?

Mr. WASHBURN. If it had any such effect as that, Senator, it would, I believe, result in a correspondingly increased price for your iron and steel products, and the iron and steel products on the farm amount to more than $4 a year of total expenditures, and the farmer would find himself—and that means agriculture, because we have got to support the farmer—the farmer would find himself in this position as the result of a governmental competition, if you can call it such, with the by-product coke-oven industry, of having what the by-product coke-oven industry lost on its sulphate—a by-product—transferred onto the cost and therefore onto the price charged, for iron and steel.

Senator KENDRICK. I understood you to say yesterday or the day before in the course of your testimony that the sulphate of ammonia, as a by-product, was produced, as it were, automatically in the production of steel; that is to say, that that by-product was essential to the operation?

Mr. WASHBURN. Yes.

Senator KENDRICK. And whatever was derived from it was in a sense that much of a gain to the business. I may not be expressing that just as you said it, but the meaning of it is that they would produce that anyway in their regular course of manufacture, and that if it was not disposed of it would be a waste; is that true?

Mr. WASHBURN. If it were not, it would become a waste; that is true.

Senator KENDRICK. The same amount would be produced under any conditions, whether there was a sale for it or not?

Mr. WASHBURN. Yes. Now, if it were not so it would increase the cost of the coke correspondingly, and the coke, which enters into the manufacture of iron, would increase the cost of iron correspondingly; that is the operation.

Mr. SCOTT. If I might ask a question there, Mr. Washburn mentioned about the farmers requiring $4 for fertilizer in a year. What size of farm does he mean, and does he include in the average the whole country? All the farmers who do not use any fertilizer at all? If the farmer is going to get away in the eastern States or in the southern States, where they must have fertilizer, that is one thing, but estimating only $4 for fertilizer, even if it is only a farm of 160 acres, is something I can not understand.

Mr. WASHBURN. Mr. Chairman, I think the next matter that I would like to bring to your attention——

The CHAIRMAN (interposing). I take it that Mr. Washburn included all the farmers in his estimate; of course, I do not know.

Mr. SCOTT. It is useless evidence unless he tells us what he does mean. It is like showing the size of a piece of steel.

Senator KENDRICK. It is true that the great majority of farmers, as you say, do not use fertilizer at all, because the majority of them, I think, are now west of the Mississippi River, and there is very little fertilizer used there. So that it reduces the number who do use it to a limited number and makes the average cost that much higher.

Mr. SCOTT. We are not satisfied with his explanation. I do not know whether you gentlemen are.

Mr. WASHBURN. A matter of interest, I know, in this situation is the fact that the Government feels that it is safe to dispose of 150,000 tons of stored Chilean nitrate if the Muscle Shoals plant is placed in operation. I would not pretend to offer what could be considered as a statement of facts in connection with a thing of that kind, but I am somewhat nonplused to understand it, for this reason: The use of Chilean nitrate by the Government for military purposes—that is, in the making of explosives, is chiefly, and I imagine enormously, greater in propellant charges than in bursting charges—that is, in what we call nitrate powders which are used for propelling the missile from the gun. The material manufactured at Muscle Shoals is a bursting charge; it is not a propellant charge, and is not expected to be, and is not suitable as a propellant.

The consumption of cyanamid, sulphate of ammonia, ammonia liquor, and nitrate of soda during the year 1918 was at the rate of 420,000 tons of nitrogen for the 12 months; 315,000 tons of this nitrogen was derived from nitrate of soda, requiring nearly 2,000,000 tons for the 12 months, or an average of 167,000 tons per month. We actually received from Chile 1,762,794 tons during 11 months of the year, an average of 161,000 tons per month.

There was used in military explosives about 250,000 tons of nitrogen during the year, of which quantity nitrate of soda furnished approximately 180,000 tons. This is equivalent to about 1,200,000 tons of nitrate of soda.

It is universally conceded by military men that the 1918 consumption would have been greatly exceeded in 1919 could additional nitrogen have been supplied. And any future war will require greatly increased quantities of explosives over the past one.

The proper reserve stock of nitrate of soda to be held in this country has been fixed at 300,000 tons, equivalent to 47,000 tons of nitrogen, by ordnance experts after the Muscle Shoals plant was proven successful. This was approximately sufficient for three months of our 1918 program. If now one-half of this is to be sold, leaving only 150,000 tons of nitrate of soda, or 23,000 tons of nitrogen, the reserve stock would only amount to the equivalent of six weeks of the 1918 program, an entirely inadequate amount. Based on the 1919 program or a greatly enlarged future one, the reserve would be negligible.

Operating the Muscle Shoals plant would produce in 12 months about 22,000 tons of nitrate nitrogen, about equal to one-half the storage of nitrate originally recommended. But in time of war it is a very different thing to have 48,000 tons of nitrate nitrogen in storage as against having to wait two years to produce that quantity. Not only would it lose the advantage of immediate readiness, but possibly also the loss of the war.

Something like 2,000,000 tons of nitrate of soda were used here in 1918, and the anticipation as it shows in this evidence here before you is that we shall use even greater quantities of explosives in the coming war, and it would seem that a store of 300,000 tons of nitrate of soda would be extremely small, and, large or small, why should the Government dispose of one-half of that material needed for propellants, because forsooth it proposes to operate a plant the product of which can not replace that nitrate of soda in propellants or replace nitrate of soda in anything.

The CHAIRMAN. Is not the product manufactured at Muscle Shoals used in the manufacture of powders?

Mr. WASHBURN. Yes; but bursting powders for bursting the shells, not for propelling them.

The CHAIRMAN. Not rifle powder?

Mr. WASHBURN. Not rifle powder.

Senator WADSWORTH. Mr. Washburn, is not the Chilean nitrate used for the manufacture of both propellant and bursting charges?

Mr. WASHBURN. Yes. In the making of nitrate of ammonia by ordinary methods, and by all methods except those employed at Muscle Shoals, Chilean nitrate is used for substantially half the nitrogen that goes into the ammonium nitrate, the bursting charge. But the quantity of nitrate of soda which is required for propellants must be many times, it seems to me, what is required for the bursting charge, and it is not clear to me how it is possible for the Government, simply because of one plant capable of producing a part of the bursting powder needed in event of war, and is not the Chilean nitrate, how it is possible to dispose of a full half of the total store held in the United States Government?

The CHAIRMAN. It is really proposed to dispose of 200,000 tons, Mr. Washburn. There is an amendment in the agricultural appropriation bill proposing to authorize the Government to loan to the manufacturing companies 50,000 tons, to be used in the manufacture of fertilizer; that is, besides the 150,000 tons. That matter has not been disposed of, but it is in conference. I mention it because it is a question that is worrying the conferees.

I think I might say this, that I doubt if an agreement can be reached carrying out the proposition of loaning it at a time when these products are necessarily high and permitting it to be returned at a time when we hope that it will not be quite so high. If it is done at all it probably ought to be disposed of for cash at the market price. I thought I ought to say this much, since we are discussing the question of disposing of one-half of the nitrate. If we have 300,000 tons the proposition really is to dispose of two-thirds of it.

Mr. WASHBURN. My point is that I do not know, and the expression of judgment would have no weight with you gentlemen, and should not have, if the Government should dispose of 150,000 tons or 200,000 tons or any other quantity. But I can not trace, and none of the gentlemen connected with our organization who are familiar with those sort of things can trace, any reason why the starting up of the Muscle Shoals plant per se should make it practicable for the Government to dispose of 150,000 tons when it was not practicable to dispose of it unless they did start the Muscle Shoals plant; and the significance, to our mind, is that the argumentative or tactical merit on the part of the administration plan seems to be a means of securing $12,500,000 without its being a direct, necessary additional investment on the part of Uncle Sam, assuming that we could sell the 150,000 tons for $12,500,000.

Now, there is another reason for that, as we see it, because it would take the Muscle Shoals plant, even if the whole thing were operating in time of war, a year, or, in fact, a year and some additional months, of full operation to produce this equivalent of 150,000 tons of nitrate of soda, and the necessity for running a year in the face of war to produce a given quantity has a totally different significance rom having that total quantity in your hands when your trouble comes to light.

The CHAIRMAN. Let us see if I understand you, Mr. Washburn: Did I understand that the product produced at Muscle Shoals would not be the product which necessarily would have to be used as a propelling force, as you call it—that is, used for rifle powder?

Mr. WASHBURN. We can not manufacture a propellant at Muscle Shoals.

The CHAIRMAN. Then, of course, that would have to be replaced in some other way than in the manufacture at Muscle Shoals. We would have to secure it from some other source than the manufacture at Muscle Shoals?

Mr. WASHBURN. Yes. It is always anticipated that it would have to be. The Muscle Shoals plant was never intended to make a propellant powder in which vast quantities of nitrate of soda are required.

There has been confusion in the minds of many who have been called upon to consider this situation as to what the relationship was between nitrate plant No. 1 at Sheffield, close to Muscle Shoals, and nitrate plant No. 2, at Muscle Shoals, and the Muscle Shoals hydroelectric power. There is no connection at all between the proposed power-development plant at Muscle Shoals and plant No. 2, the plant that we are considering here, generally known as the Muscle Shoals plant. The dam up to the present time is being built and the No. 1 plant was built out of the appropriation of $20,000,000 contained in the nitrate clause No. 124, of the national-defense act, and plant No. 2, the Muscle Shoals plant, was bbuilt out of an appropriation for Fortification C, using the technical phrase.

Now, if I understand correctly the national-defense act and the nitrate-supply clause under it, there is no legal method by which money can be expended upon a hydroelectric plant unless that hydroelectric plant is to be used for the manufacture of munitions or the manufacture of fertilizer. I do not know that even the latter would be entirely legal. The manufacture of fertilizer is not a defense act. But, however that may be, there is nothing that I can see in the act, or that our attorneys can see in it, which makes it legal for this Government to expend any part of that $20,000,000 on the Muscle Shoals hydroelectric plant unless that plant is to be used for the operation of the Muscle Shoals plant. It can not be used for the operation of No. 1 plant, because the No. 1 plant has never been operated—never has been—and it is not the present anticipation that it will be, and it does not require any such amount of power as this proposed power plant is to give.

Therefore, it seems to me that there is a necessity upon the administration, in order to legalize its undertaking in the building of that Muscle Shoals dam, that they shall find some way of operating the Muscle Shoals plant; and that brings me to the method that they propose to operate it under, and that is the bill that has been presented to you here, and I would like to make a few comments on that bill.

The CHAIRMAN. I wish you would do that while the author of the bill is present, because he is a very busy man and he is not able to be here at all times.

Mr. WASHBURN. In substance the bill creates a corporation to purchase, operate, and develop two Government nitrogen plants, Nos. 1 and 2, a quarry, and an electric power plant in Alabama; a research laboratory in Washington, D. C.; when completed to operate a hydroelectric power plant now under construction at Muscle Shoals, Ala.; and other plant or properties of the United States which the President and the Secretary of War may transfer to the corporation or for the corporation for use in connection with any of the purposes of the bill or for any purpose incidental thereto; all for a period of 20 years. The corporation is authorized to sell at home or to export the products of the plants; and to make contracts, to sue and be sued; to lease or purchase buildings or properties; to assume any or all obligations of the Government entered into in connection with the construction, maintenance, and operation of the plants; to condemn lands, materials, minerals, patented processes, etc., when so authorized by the President.

That comes from the powers of the President under section 129 of the nitrates-supply bill, which, for the purposes of this bill and for the purposes of the industry, states that the President shall have the same powers that he has under the nitrate-supply section.

The Secretary of War appoints at pleasure the directors of the corporation, who have all the powers of directors of private corporations, and in addition broad powers specifically stated in the bill.

The capital stock of the corporation, owned exclusively by the Government, will consist of common stock with no par value and $12,500,000 of preferred stock, par value $100 per share and entitled to 5 per cent dividends. All net earnings not required for organization, operation, and development of the corporation shall be used (*a*) to pay dividends on preferred stock; (*b*) to develop and improve the plant and equipment; (*c*) to create a reserve or surplus fund of $2,500,000, and (*d*) to pay the remainder into the United States Treasury.

The assets and income of the corporation are exempted from Federal, State, and local taxation.

Now, it seems to me fair to say that the effect of that bill, if enacted into law, would be this: First, it starts the nationalization of the fertilizer industry, both domestic and foreign.

Second, it starts the nationalization of electric power plants.

Third, it starts the nationalization of quarries.

Fourth, it starts the nationalization of laboratories and experimental plants, for furnishing nitrogen products to the United States "and others."

Fifth, it starts the nationalization of a so-called "self-sustaining" Federal agency.

Sixth, it eliminates the civil-service law in a Government undertaking. The board of directors of the corporation have power to appoint, define duties, fix salaries, and dismiss officers and employees.

The board of directors have $100,000,000 worth of property under their control.

Seventh, it provides for the appointment and removal of the directors of the corporation at the "pleasure" of the Secretary of War.

It provides directors who are interested financially in the corporation only to the extent of the salaries they may receive (presumably such salaries as the Secretary of War may fix). They are responsible to the Government—to all the people, to everybody and, therefore, in practice to nobody except the then Secretary of War.

It places the Government property valued at more than $100,000,000 in charge of a corporation without any obligatory return to the Government on the use of the investment.

It relieves the Treasury Department of control of the financial affairs of the corporation and provides that the Secretary of War, who appoints the directors, shall be responsible for auditing the accounts of the corporation. Even the auditing power can not be exercised by the general Government or the Treasury.

The bill permits the directors, by authority of the President, to condemn lands, materials, minerals, and processes, patented or otherwise, for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products by water power or any other power. (Sec. 124, Nitrate Supply.)

It seems to me that at this time the following very pertinent questions might be asked:

1. If nitrate plants are to be operated by the Government, why not powder plants, which are almost entirely for war uses? Why did the Government sell the $70,000,000 powder plant at Nitro, W. Va., for a little over $8,000,000? Why did the War Department take a $62,000,000 loss instead of placing the Nitro plant in charge of the directors of the United States Fixed Nitrate Corporation?

2. Will the coke ovens, built at the expense of the Government, be placed in charge of the United States Fixed Nitrogen Corporation? Coke ovens produce nitrates. Is this the meaning of the term "for other purposes," used so often in the proposed bill?

3. If nitrates are essential to the Government in war and peace why is it not logical to create other Government corporations, free from all indebtedness and taxation (income tax, State, town and country taxes), to own and operate similar necessary utilities "for other purposes"?

4. What is to prevent the Government, under the cloak of producing munitions "for other purposes," from forming similar corpora-

tions to produce food, clothing, housing, and all the necessaries of life in peace and war? Almost the whole industrial organization of the country produced munitions of one kind or another during the war.

5. Why not do away with civil service entirely by creating the United States Treasury Corporation, the Interior Carporation, a Public Works Corporation, and making all Government departments into private corporations with jobs for the faithful ad lib?

6. Do nitrates constitute a monopoly the control of which is peculiarly essential to the production of munitions? Nature's nitrates are mined in Chile (sodium nitrate), artificial nitrates and by-products of coke ovens (ammonia), and the Government has two or more processes for the artificial production of nitrates from the air. Here are at least four major sources of nitrates, and monopoly is impracticable under the circumstances.

I do not know just where the American Cyanamid Co. would stand with the power given to the Government to condemn. One of our properties that we possess is our contract with the Government. If the Government has the right to condemn property it will condemn its own contract with us; but whether it does that or not, the moment it sees there is something of ours it wants—and they want to-day that patent to manufacture cyanamid fertilizer—all they have got to do under this bill is to go out and condemn it. And yet we talk about Government competition. Gentlemen, there is not any such thing as Government competition. This is not competition with the American Cyanamid Co.; this is condemnation. It is not even condemnation——

The CHAIRMAN (interposing). It is confiscation.

Mr. WASHBURN. It is confiscation; that is just what it is. Every reasoning man knows that under such powers as that, with a question already arising as to the rights of the parties and the rights to the patents to our processes—nor are our most valuable processes involved in the manufacture of cyanamid fertilizer. But here is the Government starting out on this industry, and with specific powers which will enable it to take the one industry that has come over to this side of the Atlantic in the whole broad field of the fixation of atmospheric nitrogen and many of the attendant things that go without it, and they can confiscate everything with that bill; they can condemn us right out of existence, and not only is the power given, but the intention is there—it states it right here.

The CHAIRMAN. Of course, during a war, Mr. Washburn, we could not criticize any action of this sort if it were impossible to get this product in any other way. The Government would be justified even in condemning and in confiscating, if necessary, any property, it does not make any difference who it might belong to, in order to protect and defend the interests of the Government. I think, perhaps, we will all agree on that. But I realize that the purpose for which this product is to be used places it in an altogether different position, because this, as I understand it, is an industry; it is a product to be manufactured to be used in the industries of our Government, and not for national defense. I am not a lawyer, but I think we are giving broad powers; we are giving them the right of eminent domain; we are giving them the right to condemn; and I find absolutely no fault with that in times of war; and I find no fault with it in times of peace when the product is to be used for the national defense. I do not think any of us find any fault with that. But I raised that question when the Secretary of War was here, Mr. Washburn, and I said perhaps among the mooted questions was that it permitted the Federal Government of the United States to enter into the business of manufacturing a product, it does not make any difference in which industry to be used, it would in fact become a competitor with a private industry. I am sure you agree with me, although I think that during the war, if necessary, we had a right to condemn and to confiscate a product if used for the purpose of defending our country; and, of course, in your case it was not necessary, because you let the Government use your patent.

This is a great big question; it seems to me it is a tremendous question.

If I may be pardoned for saying it, I come from a State where our people have been denominated as very liberal. According to your analysis of the bill, this would be socialistic and communistic on a wholesale scale, the largest scale possible. I may be harsh in making that statement; I do not want to be, but am I assuming too much when I say that if this bill was enacted into law and carried to its logical conclusions that would be socialism on a large scale?

Mr. **Washburn**. Mr. Chairman, I do not know just what socialism is, but from the standpoint of the man in the street's acceptance of what socialism means and its significance, I think it is the most extreme expression of it that has ever been raised in this country. I do not know but what it is the first instance when a civilized government ever started out as a vendor of materials and as a merchant and manufacturer in competition with its own people and its own taxpayers.

The **Chairman**. Do not misunderstand me; I am not condemning it. I think it is only fair that we should discuss it. If the people want socialism, of course, I do not say they have not the right to have it—but if the Federal Government, the Government of the United States is to set up and indorse a scheme which in purpose and in effect is communistic and socialistic, then it seems to me we ought not to condemn it on a smaller scale; we ought to follow it up to its logical conclusion.

Senator **Kendrick**. But, Mr. Chairman, is it not true that the primary purpose of the bill is in the interest of the national defense; in other words, to perpetuate this great industry for the direct purpose of having it ready in case of an emergency?

The **Chairman**. That is what I would like to have discussed.

Senator **Kendrick**. Would it not be entirely conceivable that these powers should be granted and that they would not be arbitrarily exercised except in case of need? It is necessary to have this authority to act rather than to be compelled to wait for Congress to give it to the Government to operate this plant. Of course, it might be a radical step to take as a manufacturing proposition, in fact, to go into the industrial situation and upset that—that would be socialistic. But I am impressed with the idea that the sole purpose is to operate that plant and to complete it first, and then continue to operate it for the purpose of having it ready in case of an emergency, so that we would not be found unprotected in another war as we were in the last war. That is my idea of the principal purposes of the bill, and that the manufacturing of fertilizer is only an incident to that, to enable the Government to continue and perpetuate the plant without unnecessary and abnormal expense in doing so.

Mr. **Washburn**. One of the contentions of the Government is that the plant should be operated in order to preserve it. Our contention is that the best way to preserve it is to take care of it while it is idle.

Senator **Kendrick**. But, is it not true, Mr. Washburn, that experts on machinery insist that it is more difficult to protect it in idleness than it is in action and use?

Mr. **Washburn**. There are two kinds of deterioration; one is due to the elements and the other is due to attrition and wear connected with use. It is possible to protect everything in that plant from the elements. Let us analyze it for a moment as all these things have to be analyzed, because here this question of the preservation of the plant is not to be comprehended in one single thing any more than nitrogen is one single thing. Half that plant they propose to use, and that half is composed of electric furnaces, electric ovens, crushing and grinding machinery, and great boilers for the evolution of ammonia from the lime nitrogen and cyanamid. All that equipment we have used for years. This is substantially a duplicate of what we have used for years and are using it to-day. There is no part of that equipment which can not be preserved in perfect condition, so that at the end of one year it is in just as good condition as it was at the beginning of that year. The method of preserving, for instance, the electric motors, of which there are a number, would be to place them in a building in which the temperature and the amount of atmospheric moisture was under control, and they would be protected and preserved there satisfactorily and indefinitely.

The other half of the plant is an acid plant, and the great thing about acid plants is the way you eat them up when you use them. In that plant very important parts of the equipment will only last two years in use, but it will last indefinitely without any attention at all, without even paint, or watchmen ever going near it, if it is not used.

Senator **Kendrick**. Your deductions, of course, are widely different from that of the Government; and, assuming that the Government is right in their conclusions—and they undoubtedly have some very capable men passing upon this question—there would be a very great opportunity for one of two things to happen, or both. For instance, to take the cost of this machinery out of it even a very limited time, and therefore have any equity that was left in the machinery, and the other thing, in my judgment, is almost certain to occur in this as it is in other experiences, that the machinery will become for the manufacture of this product practically obsolete within a few years and useless.

Mr. **Washburn**. Let me speak to this point of the obsolescence of that machinery; its uselessness.

Senator **Kendrick**. Yes.

Mr. Washburn. It never will produce at a greater cost than it is capable of producing now; it will be just the same machinery and the same processes that would be put into use.

Senator Kendrick. That does not apply to other industries.

Mr. Washburn. It applies to every industry. The art may advance so that some other process may produce more cheaply, but this process will not grow more expensive by reason of that machinery standing there.

Senator Kendrick. The chairman of the committee and I and other farmers find that we can junk machinery that was bought five years ago, even at the high price prevailing, buy improved farm machinery and practice economies because of the advantage accuring from the improvenents in that machinery. Now, it is inconceivable that this industry and its processes will stand still when all other lines are advancing, do you not think so?

Mr. Washburn. Yes. The art will not stand still. The cyanamid art has reached that point which nearly every art reaches in time, what we call "point of standardization," and beyond that there are improvements, but they are not revolutionary ones. The locomotive on our steam railroads is essentially the same locomotive that was there in 1865.

Senator Kendrick. The same in form, though so greatly improved that the original inventor of it, the man who was responsible for the type used at that time, would not recognize the present locomotive as such; and if he examined the form of it, it is more nearly identical than the actual workings of it, as I am told by railway men, that is, in the mechanism.

Mr. Washburn. In so far as those revolutionary things are concerned, the difference between the locomotive used in 1865 and the early John Bull's locomotives of that kind, is far greater than the difference between 1865 and the present. There has been a standardization, as all mechanical engineers know, of the locomotive; there has been a standardization of the automobile. And not that improvements will not be made, but we get to a point of standardization, as it is called. The cyanamid process is at a point of standardization, so that we need not expect any revolutionary improvement in tion, so that we need not expect any revolutionary improvement in it. There will be improvements, undoubtedly.

Senator Kendrick. Just excuse me a moment. I just want to say that the principal point in my mind about the powers of the bill is that we are here passing upon questions that have direct connection with the defense of the Nation. It is essentially a war measure, just the same as in our present military organization bill, proposing, as I understand it, to write into that bill as permanent legislation a provision in connection with the selective draft. Now, that selective draft was an emergency act pure and simple. The bill as now drawn, I think, includes that, does it not Mr. Chairman?

The Chairman. I think we voted that out yesterday.

Senator Kendrick. We had it in the bill, and I think it has not been voted out.

The Chairman. If not, we hope it will be.

Senator Kendrick. And this is simply a continuation of the same plan and purpose.

Mr. **Washburn**. But the practical consideration, in so far as the operation of this plant is concerned, as a matter of national defense, lies in the difference of its effectiveness when the time shall come for the manufacture of explosives as between taking care of it in idleness and operating it.

I want to make this so clear that it can be readily understood. There is no question but what if that plant were fully in operation, going every day throughout the whole course from beginning to end, that it would be more quickly available for use in case that we needed explosives than it would be to have it idle and have to introduce a corps of men to operate it.

Senator **Kendrick**. That is an important point.

Mr. **Washburn**. The question of time would be different. It would take time to place that plant in operation. But that statement of it is not the equivalent by any means of stating that it is necessary to operate that plant in order that it may be in condition to produce explosives effectively.

Senator **Kendrick**. But, assuming the Government's estimates are correct and the plant could be operated at even cost of maintenance, it is certainly that under that condition, with constant operation there would be, in case of an emergency, a plant in operation that would be infinitely better than the plant as it stands now, provided a period of years were to lapse before the emergency arose, because here would be a constant system of evolution bringing to the plant all of the improvements that accrued to it, and when the time came for use you have a machine entirely up to date, and probably, as the department believes, it can be operated at, say, cost and without profit, in that event it would provide for the changes without cost to the Government and insure all of the advantages accruing under that plan, where we would be at a great disadvantage and have to rebuild it almost entirely under the condition that we allowed the plant to stand idle.

Mr. **Washburn**. I could not bring my judgment to accept the idea that any rebuilding would be necessary. But, granting that it is a desirable thing to operate that plant, desirable to the point that it will offset the losses in operation of it, it ought not to be operated by the Government; it ought to be operated by a private industry; and if it can be operated by a private industry, there is no reason for operating it by the Government; and it can be operated, as everybody, I believe, will agree, by private interests, under any circumstances, much better than it can be operated by the Government, because we have no instance of Government operation that is economically effective, efficient, or sufficient from any point of view. Why not search for some way, if it is the point that it must be operated, in which private interests will operate it?

Senator **Kendrick**. Is it not your judgment that the Government, with efficient equipment, could have manufactured its ammunition during the war at a lower cost than it was produced by the great ammunition manufacturers? Do you not believe the Government could have delivered that ammunition if it had been equipped at a great saving of cost?

Mr. **Washburn**. I will answer you by an example: There were two nitrate plants that stand so that you can look from one right over into the other. The Government operated one which cost $13,000,000, which can not turn out and never did turn out and never is expected to turn out a pound of product. Private interests without relationship on the part of the Government, or any Government official, except that they had the right of inspection and audit, built another plant with this record: It was five times the size of the Government plant; it was built in eight months and eight days by private interests from the time the first foundation was put in; it manufactured its product—answering your question of costs—so cheaply that had it continued manufacturing for the three years of the term of the contract the saving to the Government on that project over what it would have had to pay elsewhere was equivalent to the cost of the plant and $20,000,000 in addition. The quality of the material produced was better than any material that had ever been presented to this Government. It passed the specifications of the Ordnance Department, and in very important particulars, too. That private initiative, private control and private direction, private operation as compared with Government operation right in the thing that you are talking about, Mr. Senator, the thing that is right in front of us.

Now, these gentlement—not these particular gentlemen, necessarily—but essentially the same type or organization, or the same influence or interests, call it what you will—the same productive factor, if you can call it that, which spent $13,000,000 and got nowhere, proposes to come over into the successful private industrial plant and take possession of it, and go on with what? With another experiment, an experiment in Government operation in industry and trade and bartering, and one thing and another. They do not merely propose to do it with that simple statement of it, but by their own declarations they propose to replace in the market the material manufactured by the very company that they have driven out by operation of the Muscle Shoals plant, a private industry, and ruin it. For it does not spell anything but ruin when the Government comes along with a material that they claim they can manufacture at $48.

Senator KENDRICK. Is it your company that is referred to?

Mr. WASHBURN. It is my company, most certainly.

Senator KENDRICK. Well, I would be willing entirely to oppose any unfair practice on the part of the Government, as I believe it should be opposed on the part of any one, in connection with any kind of business or other transaction; and yet, I do not concede all you say about the impotency of the Government to get results when it attempts to do so in a legitimate way, and on an equal basis of opportunity.

As an illustration, it is perfectly proper for men who have given their lives to an industry and followed it up for it to go along at a greater advantage. The Government has not, except in shipbuilding, attempted any manufacturing, if that could be called manufacturing. I do not know of its appearance in any field of industrial life. But if it came to a period of time for equipment and preparation, I am unable to understand why the same talent that composes our citizenship under Government service would not give a like kind of results. I am one of those who believe very strongly in Government efficiency in the lines they have laid their hands to, and I have heard many witnesses come before us here in the last few months—and this is a matter of opinion—but I have heard it so much, and I think it is something of a discredit to us to insist that the Government is entirely impotent in anything it attempts to do. I do not think it is quite fair, and I know it it not quite true, for we do things and we do them wonderfully well when we lay our hands to them, either as a Government or any other way as private individuals.

Mr. Washburn. Senator, it would be very unfair unless there were involved conditions of governmental employment and activity that are inherent and so different from those conditions which make for efficiency in private industries as to make the Government operation impracticable.

Senator Kendrick. I am not anxious to see the Government invade that domain as an encroachment upon private initiative or even when it is carried on by cooperation. I have no disposition to see that done. But, as I view this situation, it is only a means to an end and incidentally means at that.

Mr. Washburn. It seems to me that there are inherent conditions attending the employment of Government servants, without any reflection upon them, but those conditions exist and prevent effective production or engagement in industry. The prizes that are offered; the natural ambitions are different; the impelling motive of profit, which is the whip behind every private industry and works out automatically, the selection and the survival of the fittest does not apply to Government work. The Government officials are in a position that does not involve those things that are properly governmental care, broadly the political matters and the guarding of our liberties and the doing of those things that are so exclusively public of their nature that they can not be done profitably and satisfactorily by private industries—yes; that is the field, and that is where, in connection with that sort of activity, we should train our public officials.

But when you come into a matter that turns upon the effectiveness with which you use materials and individuals and energy, and all that sort of thing, there is not behind the Government man any hope of profit; he has no fear of failure. We know from our experience as practical men that failure does not result in the automatic exclusion of a Government official like it does in business. He has no competitors; he has no customers to satisfy. There is no reason for hurry, no danger of being found out. He has not any of those things that produce this condition that I have encountered in my time between the man who is working for a Government and he who is working for private interests. He has not behind him that law of the survival of the fittest which, after all, is the great law that leaves us on earth, we individuals; that is the reason we are here, and not dead, because we are fittest to live.

Senator Kendrick. If your statements were true in every particular, there would be a sad situation with the Government.

Mr. Washburn. Is it not a sad situation whenever the Government inserts itself into railroads and telephones and telegraphs; is it not a sad situation when the Government goes into shipbuilding?

Senator Kendrick. Why, not shipbuilding. I was reminded you talked of this experience of ours with Hog Island. I saw a committee leave this Senate to go to Hog Island on a trip of investigation, and they had then the most pronounced critics of the efforts of the Government at that place up to that time with whom we were associated in the Senate; and they came back to the Senate entirely satisfied and even elated with the work that was going on and full of praise with the results obtained by the Government. I saw that; and I have seen something of the working of the railways. You should remember that the railroad management failed at the beginning of our connection with the war and because of the entirely impotent action or efforts of the railroads in getting any results; and I saw the Railroad Administration take the railroads over and manage them and bring order out of chaos, and they delivered our soldiers across the country, and delivered the equipments of war and carried the ordinary products of the industries of the country at the same time—its passenger and freight service; and I am one of those who believe that we did perfectly wonderful things in the operation of the railroads, and I am a shipper who has suffered as much by the war conditions as any one I am acquainted with.

But, in order to get a right conclusion on this we must understand that the railroads had failed at the time the Government took them over.

Now, as to the telegraph and telephone lines, I have nothing to say about that, but if you live out your expected time you will see the Government, probably, operate the telegraph lines yet.

Mr. WASHBURN. Did you have reference, Senator, to the construction of the Hog Island plant there?

Senator KENDRICK. I did.

Mr. WASHBURN. You would not call that Government construction, would you?

Senator KENDRICK. I suppose it was under the direction of the Government. We made appropriations for it, as I understand it.

Mr. WASHBURN. Yes; but the appropriations may have been made to pay for the work, but that was not a Government operation; it was a private undertaking; absolutely so.

Senator KENDRICK. How did it occur, then, that we were making appropriations for it, just to have the work done under contract?

Mr. WASHBURN. Yes; precisely.

The CHAIRMAN. I certainly do not disagree with my good friend from Wyoming, as far as it relates to the necessity and purpose of the Government preserving its property because of investment made during the war. Of course, I am in perfect accord with Senator Kendrick on that, and, as I said a moment ago, I think the Government has a right to do what it pleases, whether it costs more or less, if it is a case of absolute necessity; and the problem, of course, is this, Which is the better way to conserve the property? If we can not conserve it or take care of it in any other way than to do it according to the plan proposed and let it be understood that the manufacture of this product is for the very purposes that it was intended in the beginning, and then it is only incidental that we manufacture this fertilizer, that may be a different question; and that is providing we can not take care of the property in any other way.

I do not want it understood that I disagree with Senator Kendrick on that, but I raise this question because it is one we will have to face.

Senator **Kendrick**. I want it to be understood right here that I am not willing to see the Government, when it invades the domain of industrial life, work a hardship upon or penalize private industry; that is a line that must be carefully drawn; there is no question about that.

Mr. **Washburn**. Senator, the only way it can be drawn is in legislation, for the reason that it is not sufficient to say to private interests, "Your legal rights will be taken care of in the courts." The private interests can not contest with the Government in the courts, as a practical fact. The wise business man generally does not concern himself with looking forward to a lawsuit either that has been filed against his interests or one that he has an anticipation of being filed with much concern as to the result of the suit, but more with the difficulties that are involved in the attention and the expense and the uncertainties in connection with the development of your interests that are involved in the lawsuit. Lawsuits are one of the most destructive things in business to-day, not from the decision that finally comes but from the very fact of being a lawsuit. Now, the Government has a bureau, the Department of Justice, headed by the Attorney General. It is a great machine for handling lawsuits. The Government does not hesitate to go into lawsuits because of the expense and trouble; and the damage to private interests is so great that whatever the decision in the end, the damage has been done. It has been said to us, "Now, if there is anything wrong in this situation, if your patents ought not to be condemned and they are condemned, you can get your recourse in the courts."

That is simply the shifting of the responsibility of the legislative branch of this Government onto the courts at the expense and practically, in this case, at the destruction of the individual.

So it is important in legislation of this kind to so legislate that we know that private interests are not to be invaded by leaving it to the courts for decision.

Senator **Kendrick**. There is no question about that; and it is also true and a certain fact that it is going to be necessary for the Government to have due regard for the welfare of private manufacturers in the sale and disposition of any product into which it enters in competition. It will have to sell that product, it will have to base the price of that product on the opportunity of these private individuals or private enterprises to go along and prosper.

The **Chairman**. The committee will now take a recess until half past 1 this afternoon.

(Thereupon, at 12.30 o'clock p. m., the committee took a recess until 1.30 o'clock p. m.)

AFTER RECESS.

The committee reconvened, pursuant to the taking of recess, at 1.30 o'clock p. m.

The **Chairman**. Mr. Washburn, you may proceed with your statement.

STATEMENT OF MR. FRANK S. WASHBURN—Resumed.

Mr. Washburn. Mr. Chairman, if the reasons that are advanced in support of a project of any kind are adjudged not to exist, or are faulty or imperfect, it is fair to assume that the project itself is not a creditable or desirable one. It is not necessary, I take it, to assume, in order that a project shall be ill-advised, that everything advanced or argued in its favor shall be disqualified. But however that may be, and to whatever extent you give weight to the credibility of your witnesses, from our standpoint and from what we know and what has been presented to your committee, upon careful analysis, it would seem that nearly all, if not all, of these matters that are advanced as reasons why the Government should not operate this plant do not exist.

We believe there is no benefit to the farmer. We believe there will be no profit to the Government. We believe there is an excessive cost. There is no emancipation from Chilean nitrate. There is no shortage of nitrogen supply as an excuse for putting the plant into operation. It is not a matter of salvage; it is a matter of putting a part of a plant into operation, the cost of which part is less than half the total cost, by an expenditure of even more money than that part of the plant costs.

It is not necessary to the preservation of the plant, and within the limits of our limited knowledge of the subject, we see no reason or safety in the Government's disposing of 150,000 tons of its store of nitrate of soda in case that plant is put in operation.

The other matters I wish to speak to you about have to do with what I imagine are your difficulties in viewing the situation. One of them is this matter that was raised this morning as to the possible inconsistency in my attitude toward this situation and my attitude toward what has been known as the Muscle Shoals situation for many years. What I said in reference to that was that the situations are deemed to be of value when there is an effort made to occupy them, or an effort made to make a profit, as a result of an analysis and putting together of the factors that apply to that situation. And the factors to-day are very different from the factors that applied to the situation before. We have a very different sort of plant. It is not a fertilizer plant. It is capable of being transformed into one, to a limited extent at least. But the whole fundamental basis of looking forward to a great national situation—national in the sense of its importance to the country as a whole—at Muscle Shoals is eliminated so far as the conditions exist to-day, and therefore we could not hope to move into that situation until such time as those conditions there change or there is a promise of a change. Some of them, as very pertinent factors in that situation, can not change.

It was a most alluring and attractive thing to contemplate the possibility of establishing a great industrial center in the South, and particularly on the borders of the one industrial region of the South, the Birmingham coal and iron district, and to establish it on the basis of cheap water power. That was the whole basis, and that basis does not exist to-day.

Of course there have been advances and changes, not only in the factors that apply, but in the ambitions and the situations of individuals and of interests and all that sort of thing. And it is not only a very great shock to the people connected with our company but, as I will indicate to you out of the testimony of the Government itself here, a very great shock to a very large part of the American business community in its confidence in the ability of our Government to deal fairly and squarely and broadly, honestly; and that is a factor which destroys that degree of confidence that, after all, must be at the basis of any undertaking, particularly where there is cooperation. And the development of the Muscle Shoals situation always did mean cooperation between private capital and the Government.

The general considerations are borne out as to these changes in important things by the details themselves, some of which I mentioned this morning—a tremendous change in labor, a rate three times what it used to be and the efficiency not as great, a change in interest rates, and costs of materials. And there is another which may not exist at the present moment, but private capital could not count on it, that any great Government work the invesment in which is of the preponderating importance that investment in water power must be, should be constructed by the Government. The Government engineers' say-so is no discredit to them, but the conditions of Government construction are such as to make the cost of those structures very great. That is recognized by the engineers themselves, and complained of, frequently, bitterly. That whole dam and all that has to do with it, its equipment, its power stations, and all that sort of thing, should be done by private capital; because, after all, when you get through the total cost of your energy, or 90 per cent of it, is going to be in your interest account, and interest account varies directly as cost, and anything that can lower the first cost is necessary for adoption.

The CHAIRMAN. I think there is a great deal of apprehension as to the conditions down there. I think it is believed quite generally that this dam has been constructed, Mr. Washburn, that it is there already, and that all we have to do is to use it.

Mr. WASHBURN. I do not know how far along the work of construction is, but it can not have progressed very far, because they have had a very limited force at work, and not very long ago there was no indication of masonry having been erected. I doubt that there has been any masonry put in.

Senator KENYON. Mr. Washburn, are you interested in other fertilizer companies that would be affected by this in any way?

Mr. WASHBURN. No.

Senator KENYON. Or your company?

Mr. WASHBURN. Our company would be affected by the way in which the Government complied with its contract with us.

Senator KENYON. Is your company interested in fertilizer plants?

Mr. WASHBURN. No. No; we have no interest in fertilizer plants. I know it must be true that a very proper and very puzzling question, in connection with past matters in which the American Cyanamid Co. has appeared in Washington and in connection with this matter, has been to know what the motives of the Cyanamid Co. are.

In the parlance of the street, What is the game of the American Cyanamid Co.? What is it here for to-day, and what was it here for in the past?

Senator KENYON. That is one of the things that has been bothering my mind.

Mr. WASHBURN. It is very proper that it should be. I wish there were some sort of device for the determining of people's motives and intentions to correspond to the X ray in medical science. I should be very glad to have the X ray applied to this.

Anything that I say must be colored in your minds by the doubt as to whether I am entirely honest in the statement of it, and for that reason it seems to me important to take just a few mintues in looking back upon the history of the company in the past. We do not now have to look forward, as we did from 1906 when were first came here, to see what it was that the Cyanamid Co. was trying to do, what it did do, and whether its efforts were wise. But we can look back and see what it did stand for, and measure it in the light of the developed facts, as to whether we stood for anything that was discreditable to us in any sense.

The impelling motive that the Cyanamid Co. has is to create an opportunity in which they can earn money. Money is an expression of activity. It is a desire of the American Cyanamid Co. to be profitably busy, and that, I take it, is the desire of every healthful man and every healthy organization of any kind in the world. It is not discreditable.

When we made an effort here, with $4,000,000 at our command, to get permission to develop the power of the Coosa River for the sole purpose of making a fertilizer and it was refused to us, we were accused specifically of being in the same class with timber grabbers—that was the term used—we were trying to take away from the people of this country water power which belonged to them.

If the effort on our part to make money by developing the power of the Coosa River is a crime, why, we were guilty of it. There is no question about that. But what had the Government done to invite its citizens to commit this heinous crime? There was the general dam act of 1906, which was replaced by a new act, the general dam act of 1910, which set out what the qualifications must be of a plant for the privilege of erecting a dam on a navigable stream and developing power in that navigable stream.

There was no money to be raised in New York or in this country, and that project was attempted and fostered and developed by me and the capital secured in England. And what did I say to the English people? I showed them that law. I said, "Gentlemen, here is the law passed by Congress. This is what you have to subscribe to. It is substantially an engagement on the part of the United States Government that when you do subscribe to that you will be entitled to build a dam, and of course, the whole purpose of the legislation is to develop and foster the industries and the country."

Certainly if we had been allowed to develop water power down there in the wilds of Alabama it would have been a very good thing for the State of Alabama and a great thing for the country. I do not suppose anything the American Cyanamid Co. has ever done contributed so largely to a bad reputation here in Washington as our effort to build a fertilizer plant by the development of power on the Coosa River.

Now, there was a long period of effort on our part to bring about Government cooperation in the development of power at Muscle Shoals. That began in 1906 and substantially ended in 1914 by our making a competitive proposition to the Government for the construction and ownership and use of that water power. That contemplated on the part of the Government an expenditure of $16,000,000 and on the part of the company ultimately $80,000,000. The whole thing was open and above board. The hearings were entirely open. The years of consultation with the Engineer Corps of the United States Army were all open. There was not anything in connection with it that is not a matter of record and in public documents.

And if that thing had been done we would have had power down on the Tennessee River to-day for somewhere in the neighborhood of a third or a quarter of what it can be produced for to-day—that is, the energy would have cost that much less. And the Government would have owned this property, as it never went out of the possession of the Government, and would have had it paid for, together with compound interest, and it still possessed it at the end of the lease period.

Now, whether that was a desirable thing for the Government to enter into or not—it evidently considered it was not—that certainly was not discreditable to the American Cyanamid Co. But why should anyone ask the motives of the American Cyanamid Co. in that connection—or, rather, the motives of the interests which were associated with the American Cyanamid Co., which were the power interests in that case.

The response to the invitations of the Government departments in 1915 with a suggestion for a plan under which the Government would expend $20,000,000 and private interests $24,000,000—that was merely another suggestion, this time upon the invitation of the Government, for meeting the cloud that was seen on the horizon in connection with this nitrogen situation. The motives of the company were, very frankly, to be active, to be profitably active, and to make money in that situation. But it was never urged that the Government should do anything for the purpose of enabling the Cyanamid Co. to make money; the point was that there was a natural place for a copartnership, and the right kind of a copartnership, in which both parties were to profit.

The view that was held of us, whether it was right or wrong, resulted in an amendment to the nitrate section of the national defense act of June, 1916, providing that the plants for which this appropriation of $20,000,000 was made should be operated solely by the Government, and not in connection with any other industry or enterprise carried on by private capital. That eliminated us from Washington. That was the verdict of the legislative branch of the Government. That was the way they wanted to deal with that situation. We never have made any effort or taken any part in any effort at Government cooperation since. That was the most disappointing and unjust result that I can imagine for an honest effort to be busy like any other men.

The CHAIRMAN. As I understand it, the only revenue your company has derived is simply from the lease of your patents?

Mr. WASHBURN. Up to the present time; yes. The company has had an income in connection with its relations with the Government that have followed this, but those relations were of a very different sort.

The next approach to the Government was in connection with information given the Ordnance Department in April, 1917. That was just volunteered, as any other citizen of the United States with important information would be desirous of conveying it to the Government on the chance that it might be of some use.

The next touch with the Government came out of a perfectly clear sky in the request upon us to undertake to provide this Government with absolutely necessary explosives, in a very large quantity, that could not be secured by any other means or from any other individuals at all. In that connection we wanted no profit. We considered that to be our war work. That bore no relation to the past at all. There was nothing in that that brought up any suggestion of the past, and we went further than was ever contemplated, technically and every other way. We not only built a cyanamid plant, but went away beyond that into ammonia, and from ammonia into its oxidation into nitric acid, and from nitric acid into nitrate of ammonia, all of the processes, the whole thing, being under the arts and within the knowledge and the practice of the American Cyanamid Co., but for a totally different purpose—to provide this Government with necessary explosives.

The kind of contract that was made there was not of a sort that by any fair view, it seems to me, can be considered to have been discreditable to the American Cyanamid Co. We did not seek it. We did not want it. It was disaster to us to have to undertake that sort of thing. Our only contention with the Government negotiators when the contracts were made was that while we wanted nothing for our war effort, we must have our industry protected after the war against these great plants that would be built and would go into competition with our company and actually wipe it out of existence.

Now, we have no profit to show, when our taxes are paid. We have paid bills that the Government in the nature of things can not repay to us, notwithstanding the contract that they will. There are certain things that in the nature of things can not be paid—without any reflection on the Government officials—and we have paid for the organization which we contributed and offered to the Govenment for nothing, which was a very valuable one. During the course of the time they served the Government we paid salaries of over $200,000.

When those things are all paid the book profit alone is an infinitesimal amount, and from that there should be deducted the loss to our company from not having its organization there to take care of its regular business. So that from any point of view we were absolutely cut off short, so far as the American Cyanamid Co.'s relations with the Government down there were concerned, with the request on the company that it should undertake—what? Not as a contractor, to build something, but as a responsible organization to deliver into the hands of the Government something. That is the way our contract reads. And we had the designing, the planning, the purchase of the sites, the selection of the sites, the construction of the plant, and all that goes with the building of the houses, permanent and temporary, the fire department, the hospitals, and all that sort of thing, and then the operation of the plant. When the armistice came shortly afterwards we stopped the operation. Now we are out, the plant is shut down, and we are doing nothing.

Now, we could not have had any motives in connection with this matter of our relationship to the thing that is now in front of us. We were just like a soldier or anybody else that was asked, or impressed, or brought into the service of the Government to fight a war, and we did it. And while I do not think it is a discredit to anyone to have profited in a reasonable way out of a contract with the Government during the war, if there were any discredit in that fact, it certainly would not apply to the Cyanamid Co., because we have not profited financially out of it. One thing that was perfectly right and proper we should have out of that situation; the thing we stood for was protection to our industry after the war was over.

An interesting thing, showing how the fates have dealt with us in this matter, is this: Fifteen months after that clause was put in the national defense act, prohibiting any relationship at all between the Government and private interests, this Government was begging the very same private interests that were aimed at in that bill to help it out of the difficulty which it otherwise could not have escaped from. Cooperation or anything of the kind was out of the question; it went away beyond cooperation; it was simply a matter of the Government's depending entirely and exclusively upon private capital.

It seems to me we are entitled, then, to be judged by past performance, and that is the past performance. It has been given in detail in my earlier testimony; this is merely a summary of it.

Now, the question arises, What is our present motive? Before we think of motives let us consider the place that the Cyanamid Co. has at this time. It has now a definite and fixed place, for the first time in this situation with the Government, because we are partners with the Government in that plant, partners under a contract, and the relationship of partners one to the other must be judged in the light of that contract, and not only in the light of the contract but of the purposes of the Government negotiators with whom that contract was made. Therefore, it seems to me, in the opinion of anyone, however captious or critical he may have been of the Cyanamid Co. in the past, we are entitled to come here now and be heard. The rights of the Government in that Muscle Shoals plant, in one way of expressing it, are only the rights delegated to it by the American Cyanamid Co.; it is only a question what those rights are. So it is the wrong time, of all times, to ascribe ulterior motives to us, any more than we would ascribe ulterior motives to the directors of a company who sat down for the consideration of a piece of business that was of mutual interest.

Now, our motive at this time is chiefly to defend ourselves from losing our property through Government imposition. That is the thing that confront us. A second motive is to have our contract respected and lived up to by the Government without the necessity of being obliged to defend ourselves in the courts. Because, in the very nature of things, we can not defend ourselves against the Government if the Government undertakes an act which we feel is unjust and in violation of our contract. It works out that way for reasons I have already given in my testimony.

We have another motive involved in this same consideration of self-preservation, and that is to find some way under which to achieve the very natural ambition that the Government and every right-thinking person has, to put that plant into operation. That motive would come, if from nothing else, from a sense of self-preservation, because as practical men we realize that we are very likely to be run over here regardless of any consideration of any sort unless some way can be found of using that plant. Therefore you have got us absolutely on the run in this matter and are getting our best efforts, and always will, to find a way of putting that plant into operation when it is practicable to do so and just as early as it is practicable to do so. I am speaking of motives now, and that is one of the motives.

Of the general class of motives, that one of trying to save our property from confiscation—because that is the equivalent of Government competition, as I will show you later—and to preserve what we have and not to have visited upon us the thing that we fought so hard against from the beginning and which the Government negotiators were also anxious to relieve us from, the ruination of our company through competition by these plants. You do not have to look any further now to find a motive. It is very simple. You do not have to consider any motive that we may have, for instance, in connection with the Muscle Shoals dam. I know it has been the suspicion for a long time that there was some kind of political conspiracy, if you can call it such, for the investment of great sums of money down in that region purely as a local advantage, as it is to any community to have money spent in it. That never did exist and it certainly does not exist to-day, because our fear and our contention is that to build that dam at three or four times the cost it ought to be, or at any time of high cost, is to destroy the very things we have been so ambitious for and for which we have worked for years, and that is the establishment of a great industrial center about Muscle Shoals, in northern Alabama.

So much for motives. We therefore come to this other question, what to do with that plant. That is a proper question in reference to any plant or anything that the Government has. We recognize that under the circumstances at the same moment it is fair for the administration to inquire what is fair to the American Cyanamid Co.

For the moment I am not stating what I believe to be fair, but am asking the question, Should they seek the ruin of the American Cyanamid Co.? That sounds like a strong phrase. It sounds like an assumption on my part, I have no doubt. That is a cheap way of interpreting something that may be said, putting it into language that is different and giving it a force and interpretation that was not intended. That is not my purpose, and I think I will show you from the Government's own testimony that it is not an unfair question for me to ask. Should they seek the ruin of the American Cyanamid Co., first, by taking away its customers and swamping the markets at low prices, which the Government can do, because its proposed corporation will pay no taxes, no interest, no depreciation?

The proposed corporation can—not that these gentlemen who are now very heartily interested in this thing from the standpoint of the Government would do it, but dealing with the matter in its general aspect, without reference to any particular individuals, a corporation can, like the Government Shipping Board or the Railroad Administration, conceal its losses while living on its working capital. They have a working capital here of $10,000,000, provided out of the $12,500,000 to be raised by the bill.

Now, is it proper to seek the ruin of the American Cyanamid Co. by operating without profit and employing that as a reason to influence arbitrators to a depreciation of royalties? One answer to that may be that we could go into the courts, but I have dealt with that matter a number of times and have shown that it is impossible for private individuals to get redress in the courts against the Government. It is not worth the effort.

Is the administration right in believing that the American Cyanamid Co. must be wrecked to insure a return on the Government millions? Why it is not necessary for the Government to operate that plant in order to accomplish reasonable purposes and advantages I am going to try and develop for you in the next subject that I am going to deal with, and that is the plan of operation. But I will drop that for the moment.

Is the administration right in believing that the American Cyanamid Co. must be sacrificed in order that a return on the Government millions may be insured to it? I believe that is not necessary, and why I will develop later.

This brings us, it seems to me, to the great determining principle, because suppose that the return to the Government and the preservation of the American Cyanamid Co.'s rights can not be reconciled, which should prevail? Suppose that the Government's interests there in profit making and manufacturing, with the following effects upon industry, upon agriculture or anything else, are incompatible, irreconcilable, with the preservation of the American Cyanamid Co.'s rights and its existence, which should prevail in that situation, the Government or the Cyanamid Co.?

That brings me, gentlemen, to the thing that has puzzled a great many people, and has puzzled all of us in consideration of this question for a long time. And the question which expresses that principle is, Who is going to pay for this war?

Now, if the Government is going to pay for the war it should await the development which sooner or later will permit the observance of the contract with the American Cyanamid Co. and the purposes of that contract. The Government should wait for that. Merely because the Government wants a thing and wants to move is no reason or cause for doing it.

If the American Cyanamid Co. is injuriously affected by the aperation of that plant by the Government, it will, in addition to its taxes that it pays anyway, lose a large part of its capital, a large part of its business; it will be driven out of the markets, driven out of business, except to that limited extent that it has a business with which the materials manufactured by the Government would come in competition; and in that way the actual and proper earnings, the anticipated earnings, and everything that the American Cyanamid Co. has would be contributed toward paying the cost of this war. I do not see that you can get out of it; it is a logical conclusion.

After all, the American Cyanamid Co. can not pay for the whole war, and if these two interests at the moment are contradictory they should be reconciled, it seems to me. And it is the Government's business to pay for the war and not drop onto the American Cyanamid Co. any part of it, any more than its just proportion of taxes, like any other concern.

On this question of whether the American Cyanamid Co. would be ruined, which I said sounded possibly like an exaggerated statement, I would like to read something from the testimony that has already been given.

Before I do that I should like to speak on this phase of it. If the Government can not afford to protect the American Cyanamid Co.'s rights it is because the present conditions do not justify operation by any interest. It has been claimed that this company was holding out on the Government, declining to have anything to do with the plan, because it expected some day to buy it cheap. The accusation has been made that we do not want to interest ourselves in the operation of the plant because we are waiting for profits out of the royalties. If we were expecting profits out of the royalties we would not be opposing Government operation, I should say. I never have proceeded from such short-cut reasoning, but I should imagine that a man whose outlook was small enough to conceive the idea that he would do something to keep out of operating in order to enjoy the royalties would also take the view that the way to get royalties would be to encourage the Government to operate the plant and have it run and get his royalties.

The truth is, the time has not arrived for the operation of that plant, and I think the Government itself has given you that. On page 85 of this record they say:

> The American Cyanamid Co., relying upon its contract with the Government to receive a considerable compensation in the shape of royalties, without any obligation of responsibility, prefers this means of getting money out of these plants to taking commercial risk in operating them, as evidenced by its president in his testimony before the Graham committee. One of the provisions of the contract between the American Cyanamid Co. and the Government is that after June 1, 1921, the royalty to be paid the American Cyanamid Co. shall be determined by arbitration and it will be so determined in strict accordance with the contract. I do not think their payments will be very large; the estimated profit does not show sufficient earnings on investment to warrant the payment of large royalties.

And when he says—this is the part I want to come to:

> And thus we are left high and dry, and are confronted with the question: "Shall we permit these plants to remain idle and decay, or shall they be operated on a self-sustaining basis by a Government-owned corporation?"

Now, at the bottom of page 84, the last paragraph, the same witness, Mr. Roberts, has this to say:

> The question naturally arises: "Why does not private industry undertake the operation of these plants?" I shall not attempt to give what is in the minds of those who are most interested in the production of nitrates in this country. All I can state is that months of time was expended attempting to get the fertilizer industry interested in taking over and operating the Government plants. The presidents of all the large fertilizer companies in the United States were seen and the matter fully discussed with them, and they were asked if they would undertake the operation of these plants if they were to pay no rental to the Government until they had received 9 per cent on their working capital and after that the profit should be divided between them and

the Government. A part of the agreement was that the United States would complete the plants so as to provide storage and bagging facilities, a sulphate of ammonia plant, and all the work outlined in Mr. Glasgow's letter of October 22. But they could not be brouhgt to the point of making a formal offer. An effort was also made to get certain financiers in New York to undertake to form a company to operate these plants. Scant consideration was given to the scheme and no investigation undertaken. An appeal was likewise made to the coke-oven interest, with the same result.

Certainly if there is anyone who would know whether those plants could be operated profitably, the coke-oven industry, which markets fully 90 per cent of all the sulphate of ammonia that is produced in this country, should know. Then he says:

There seems to be a decided antipathy of capital to engage in any partnership arrangement with the Government.

Apart from the question of the Government's right to lease that plant without making any arrangement with the American Cyanamid Co. to that end, it is very clear that among all these great business men engaged in this industry there was no belief that the plant could be operated profitably at this time, but when the time shall come when operation is justified it is our confident belief that it can be done with justice to both parties.

That brings us to a consideration of plans for operation. They come naturally out of what has gone before in the presentation of this matter from my point of view, and they are very easily summarized. The first would be to defer construction of the dam and hydroelectric power plants to a more opportune time. For if you build them now you never will get anything that relies upon cheap power at Muscle Shoals. The chemical plant, the Muscle Shoals plant, should be held in reserve under conditions of minimum depreciation until conditions are such that commercial use can be arranged for them so that they may have their maximum economic advantage to the country.

This can be done in a number of ways. It may be done by a sale, in whole or in part, subject to a contract with the purchaser that he shall always keep the plant in such condition that it can be turned over for Government operation in the manufacture of ammonium nitrate, the explosive material, at any time the demand is made by the Government. And the conditions and payments to the purchaser under those circumstances can be made—as we had already suggested in an earlier negotiation with the Government prior to all this—at any profit that the Secretary of War in his judgment may think the company is entitled to.

The average right-thinking man—which means that that right-thinking is reflected in this corporation—when a war comes on would not want any profit out of the operation of that plant for war purposes. There it is, in private hands, in operation, some portion of it at least, with a trained force; and when the Government finds use for it, there it is just as certainly as if it were being operated by the Government itself.

In a lease made either to the American Cyanamid Co. or to anybody else there may be fixed terms of various kinds. A fixed rental of so much a year would, I think, be impracticable there. That would be speculative, and at almost any time in the history of that plant would be based upon forecasts that you could not hope to have accurate. You do not know what will become of the plant or what the future of it may be.

Another way would be the fixing of rental by a royalty on the unit value of the material produced—so many cents of rental for each dollar of product. But that is not as good a method, I think, as the other one, and that would be for private capital to go in there under a lease arrangement by which private capital would first receive interest upon the money that it invested and used there. That rate of interest would have to be determined at something fair and reasonable under the conditions existing at the time, the interest rate, the degree of risk, the outlook of the market, and one thing and another. But in principle, whatever that rate of interest might be, the first of the earnings out of that plant should go to the man who now takes the risk of putting it into operation as a commercial venture.

Then, out of the remaining earnings the next payment should be the interest to the Government upon the value of that part of the plant which is in use. That would be the value of the plant at that time, and it would have to be the result of an appraisement, probably, but those appraisements are things that are very commonly done, particularly in large undertakings.

We then have out of the earnings, first, the interest to private capital. That is for the initiative and responsibliity of running it, and all that sort of thing. Then the Government would come along with its interest on the value of such part of the plant as was being used by the private interests. Then the remainder of the profit would be distributed in equitable proportions between the Government and the private interests.

There we have a copartnership of the right kind. It is mutual, it satisfies the requirements of both parties, and the mutuality is not only in the fact that both get profits, but those profits move up and down together with whatever the trade developments may be—over which, of course, no one has any control.

Now, the administration seems to have had a plan, and that was to offer to private capital the whole plant, without payment on the part of private capital either toward the principal in the construction of the plant or for any lease, insuring to private capital 9 per cent upon the money, that it should put in, and then afterwards dividing with the Government. No such proposition, I might say, or any other, was ever made to the Cyanamid Co. But I do not know that that is pertinent or has any significance at all. I am not saying that from anything that was said to us; I am saying it out of the testimony that was given here before your committee.

It is a question of waiting until the conditions that face the world have ameliorated and been adjusted, so that there is some sense and profit and value and significance in the operation of that plant and in the use of the product, and when that time shall come it seems to me it is proper for private interests to handle it rather than the Government.

Now, apart from all the questions of equity, law, right, etc., there is a broad question of fair play, and that is far more important to the Government than anything else. Lack of fair play on the part of the Government to its citizens to-day has just as much significance as in the old days when it was an aggression against some particular individual, in the matter of taxation without representation, or something of that sort. This matter in particular is politically chiefly a question of imposition by this Government on some of its citizens.

Nothing has pleased me more in these hearings and my experience here in the last three days with you than the expressions that members of this committee have made of their determination to see that fair play is had, and I do not want to part with you at this time without thoroughly establishing my conservatism in the belief that fair play is not intended by the administration.

I am going to close by reading you a few extracts which prove to my mind that there is one definite purpose on the part of the administration—not one, but two quite definite purposes, and they are equally stressed. One is Government operation, and the other is the ruination of the American Cyanamid Co.

One page 22, in the last testimony given by Mr. Roberts, he says:

> Well, you see, it is this way: We start out and gradually build up our plant, and we would get at the end of the first year up to about 88,000 tons of sulphate of ammonia and something like 30,000 tons of cyanamid to some of the fertilizer mixers. The fertilizer mixers can to-day probably absorb about 60,000 tons of syanamid. But, of course, the American Cyanamid Co. would probably supply half of that. You know, it is being used daily in the mixture of fertilizers.

This market will be entirely saturated with 36,000 tons of fertilizer, and at the sale price proposed here by the Government they would have all of the business, or if the American Cyanamid Co. tried to have any part of it it would lose money on every ton.

On page 59, in Mr. Roberts's testimony, he says:

> We only expect to sell a small part of our output as cyanamid to go to the fertilizer mixers, who now buy from the American Cyanamid Co., and, of course, as the fertilizer business grows they will use it more and more as they mix more tons of fertilizer.

There can not be any doubt that it is the purpose here, and the definite purpose, of the Government to engage in the manufacture of cyanamid fertilizer, which under the contract we claim it has no right whatsoever to do. It is not provided for in the contract. But apart from the question of whether it is a right that the Government has or not, it violates the very purpose of the negotiators and the thing that the American Cyanamid Co. was relying upon, namely, that it should not be ruined or subjected to great loss by the operation of these plants in competition with it.

The CHAIRMAN. In other words, if it should prove to have a legal right, it would not have a moral right?

Mr. WASHBURN. It would not have a moral right; no, sir. But so far as disposition is concerned, it goes without saying that if the American Cyanamid Co. had to meet the competition of this Government in that material the Cyanamid Co.'s trade would go down, naturally.

The CHAIRMAN. You have reference now to the prices quoted in these hearings, I suppose?

Mr. WASHBURN. Well, yes. Those prices are merely an indication of how serious it would be.

The CHAIRMAN. But, as I understand you, it would be impossible for your company to compete with the Government at the prices named?

Mr. **Washburn**. Yes; that is correct.

Now, as to the other aggression against the Cyanamid Co., I wish to call your attention to page 90 of these hearings:

> Secondly, the period from June 1, 1921, until the completion of the hydroelectric power development. During this interim the operating fee is no longer payable, and the royalty payable to the American Cyanamid Co. (nominally about $6.83 per ton of dry cyanamid, or 26 per cent more than the combined operating fee or any royalty previously payable) is subject to arbitration. Inasmuch, however, as royalty is measured by superearning power, it seems certain that little if any royalty would be assessed for the use of a process which does not pay Government bond interest upon the reproduction value of the essential plant required.

I have given this matter a good deal of consideration, and the more I examine into the anomalous claim that a government with the ambitions expressed here for operating that plant, and selling its product, not in the ordinary commercial way, but selling it without a profit—that it for that reason should not pay the royalty fixed in this contract is the most arrant piece of nonsense, gentlemen, that I have seen in this whole situation. Can anyone tell me any reason at all, whatever the purpose and the reason and the obligation of this Government to pay a royalty on our patents, why we should not have anything if the Government chooses to put that plant into operation and operate it without profit?

Senator **Wadsworth**. Mr. Washburn, is there anything in the contract which makes the payment of a royalty dependent upon profits?

Mr. **Washburn**. No; nothing whatever.

Senator **Wadsworth**. Is it merely a flat royalty, per unit of product?

Mr. **Washburn**. It is a royalty per pound of nitrogen, and the contract states that if either party is dissatisfied with the royalty it may appeal to arbitration to have it modified.

Now, I am not speaking of the legal right of these gentlemen to ask for the fixing of a different royalty from the one that is fixed. That is not the point. Conditions may very readily arise from which the royalty, from the standpoint of the American Cyanamid Co., may not be large enough, and from the standpoint of the Government might be too large. But to pillory us to start with on the basis that that royalty will be reduced because the Government does not have to have or does not choose to have a profit out of a plant operated under these circumstances has no foundation in fairness and is totally opposed to the spirit with which this thing was approached by the Government when we were begged into this situation, and destroys the very thing that we all started out to accomplish, namely, 100 per cent accomplishment for the Government in what it was facing in the war, with protection for the private interests that afforded that protection to the Government in industry after the war.

The **Chairman**. As I understand it, you question the right of the Government to use it for any other purpose than that which you have just named? That is, the contract you have with the Government was for war purposes, using your patent for the manufacture of nitrogen explosives; is that correct?

Mr. **Washburn**. That is correct. But the Government has the right to put this plant into operation and produce the product that it intends to produce, and has so announced here—sulphate of ammonia is the principal product that it purposes to produce—and to sell that in the markets. It has that legal right.

The CHAIRMAN. For any purpose whatsoever?

Mr. WASHBURN. For any purpose whatsoever. It is entirely foot-loose to do that.

There is nothing more I can say. There is only one thing I would like to do, and that is to send in to you some matters that were referred to this morning and one or two other matters that have arisen here that it has seemed worth while to take your time for. I will send those in written form.

Also, if there is any testimony introduced here after mine that you can not make consistent with mine, or is in opposition to what I have said, I would like the privilege of explaining, if I can, the inconsistency, or admitting, as I should be very willing to admit, any errors that I have made.

I would like to ask some of my associates here if there is anything they feel we ought to introduce more than has been introduced. (After a pause.) There appears to be nothing more, Mr. Chairman.

Senator WADSWORTH. Have you been asked, Mr. Washburn, about the organization of the American Cyanamid Co.?

The CHAIRMAN. No; he has not.

Mr. WASHBURN. No; nothing has been asked about that.

Senator WADSWORTH. Can you tell us something about the organization of the American Cyanamid Co.?

Mr. WASHBURN. The history of its organization?

Senator WADSWORTH. Yes; and what relations it may have with other corporations.

Mr. WASHBURN. The American Cyanamid Co. was organized in 1907. Its first capital of $1,000,000 was subscribed by my three associates and myself, equally. We started out with an experimental million dollars, to see what we could do with the situation. The matter developed satisfactorily, and we sought capital and secured it abroad. It is the kind of an undertaking that American investors are not accustomed to. We think here in terms of physical property and physical assets, but people abroad have had a wider experience in things of this kind, and they give a value to an idea—and we had practically nothing but an idea to sell.

The property of the company to-day has a value of something like $10,000,000, and as fresh capital was required it was, in about equal part, furnished from abroad and by American investors.

We are the owners of two subsidiary companies. One is a large producer of phosphate rock, in Florida—the Amalgamated Phosphate Co. We own all the stock of that company. We purchased it from the former owners, who were a number of people, for the most part fertilizer manufacturers who had combined their phosphate rock holdings. The name of the company was significant—the Amalgamated Phosphate Co. It was an amalgamation of the phosphate properties of a number of fertilizer companies of importance, most of them. That company we operate. Of course, that has nothing to do with nitrogen.

Our purpose in purchasing that property was to furnish us with the raw materials for a product which is a form of ammonium phosphate and had the trade name of Ammophos, which we export in large quantities.

The other subsidiary company is this Air Nitrates Corporation, which performed this service for the Government with which you are familiar.

There is one other company, and that is a California company which manufactures hydrocyanic acid from cyanide which this company also makes. We make cyanide from cyanamid at our plant, and we ship the cyanide to our California plant, owned by the subsidiary company there, and it is transformed into hydrocyanic acid. That is a growing and important business, and the acid is used for fumigating citrus fruit—oranges and lemons. It has a large and very valuable use in that connection. One of our large stockholders is Mr. J. S. Duke, who has for a long time felt an interest in this matter of the fixation atmospheric nitrogen. He himself expended about $750,000 in efforts to develop a process, and out of the associations and mutual interests that grew up in that matter Mr. Duke came in as one of our stockholders.

Does that answer your question?

Senator WADSWORTH. Yes, sir. Has the company any interest in any of the larger fertilizer manufacturing concerns?

Mr. WASHBURN.. None whatever.

Senator WADSWORTH. Have those companies any interest in yours?

Mr. WASHBURN. They own stock by reason of the purchases that were made of these phosphate properties in Florida.

Senator WADSWORTH. Which ones are those? Do you remember?

Mr. WASHBURN. What distribution of this stock there is between companies and individuals connected with those companies I can not say. I do not recall. It is a mere matter of lack of recollection on my part. But of those that are interested, the Virginia-Carolina Chemical Co. has stock. Baugh & Sons—I think there are three of their companies that have stock. There are three of those companies, and each one of them contributed something in the phosphate properties, and naturally when we paid for the companies there was a distribution of stock.

Senator WADSWORTH. They took stock in payment?

Mr. WASHBURN. They took stock in payment. Wilson & Toomer are interested. I believe that is all of the fertilizer manufacturers.

Senator WADSWORTH. What proportion of your entire stock do those outside fertilizer companies own?

Mr. WASHBURN. I think it is about one-sixth; it is not over that, anyway, and may be considerably under. It is a matter that is not fresh in my mind, because that is something we forget about, just as we would with any stockholder. We have no relations with those companies by reason of their being owners of stock, or anything of that sort.

Senator WADSWORTH. Then they do not control your corporation?

Mr. WASHBURN. Not by any means.

Senator WADSWORTH. Nor you control any of theirs?

Mr. WASHBURN. No; there is not control of one company by another.

Senator WADSWORTH. Is there much interlocking among the several directors?

Mr. **Washburn.** No; there is no interlocking—that is, what you might call reciprocal interlocking. The Virginia-Carolina Chemical Co. is represented on the board of directors of the American Cyanamid Co., but we have not representation on their board or any interest in their business. They do not have representation there, you understand, as the Virginia-Carolina Chemical Co., but certain officers of that company are on our board as individuals.

The **Chairman.** Some of the stock of the American Cyanamid Co. as I understand it, is owned by foreign capital?

Mr. **Washburn.** Yes.

The **Chairman.** Is the majority of the stock owned by American citizens?

Mr. **Washburn.** Oh, yes; about 70 per cent—well, more than 70. We will say 75 per cent is owned here and 25 per cent abroad.

The **Chairman.** If there is nothing further, Mr. Washburn, the committee is very much obliged to you.

Col. **Burns.** Mr. Chairman, Mr. Washburn has painted a picture of this Muscle Shoals problem that is very materially different from that seen by the War Department. We do not admit that his picture is correct and that our picture is wrong, but the Chief of Ordnance has directed me to state that he proposes to have a complete study made of the points raised by Mr. Washburn, and directed me to ask you for an opportunity to present the results of that study.

The **Chairman.** I am sure you will have that opportunity.

Col. **Burns.** We have not challenged his statements as they came along, but are going to study them and propose to challenge them later on.

The **Chairman.** Very well; you will have that opportunity.

(The additional data subsequently submitted by Mr. Washburn are here printed in full, as follows:)

(This statement will be found in the statement of Mr. Landis.)

The **Chairman.** Now, Mr. Scott, the committee will be glad to hear you. Please give your name to the reporter and state whom you represent, your occupation, and so on.

STATEMENT OF MR. ERNEST KILBURN SCOTT, CONSULTING ENGINEER, NEW YORK CITY.

Mr. **Scott.** My name is Ernest Kilburn Scott, and I reside at 206 East Sixteenth Street, New York City. I am a consulting engineer. I represent only myself. I have been in this country rather less than two and a half years. Before that I was in England for about two years with the ministry of munitions, part of the time with the explosives department.

Immediately before the war I was consulting engineer and part-time lecturer at the London University in electrical engineering. Previous to that I was for four years in charge of the electrical department of the University of Sydney, New South Wales. I dare say that is as far back as you want to go.

The **Chairman.** You may proceed in your own way, Mr. Scott.

Mr. **Scott.** I do not not want to appear egotistical, sir, but in order that I may establish the point that I am in a position to speak with some authority on this, I would like you to bear with me while I go into some particulars about my connection with the nitrogen industry.

The CHAIRMAN. Very well.

Mr. SCOTT. I was one of the engineers with a large firm in London, in charge of the estimating department and designing, when 19 years ago a Mr. Howles, from Manchester, came to our firm and asked for permission to carry out some experiments, which he wished to be secret. He wanted the services of an engineer to help with the electrical work, because he was a chemist.

Now, Mr. Howles was the associate of Mr. MacDougall, who, I believe, was the first man to make nitric acid from the air. The English patent is 4643 of 1899.

Bradley and Lovejoy got busy in this country with a rotating furnace giving numerous direct-current arcs (American patent, 709867 of 1902; English patent, 8230 of 1901), and Birkeland and Eyde, in Norway, built furnaces having magnetically blown arcs and requiring both direct current and alternating current (Norway patent, 13240 of 1902).

We worked with alternating-current arcs blown into flames by a current of air, the arc flames being made steady and continuous by a choking coil.

In 1903 I went to Norway in connection with the evaluation and the testing of a carbide-of-calcium plant in Norway. While there, of course, I heard what Mr. Eyde and Prof. Birkeland were doing, and that aroused my interest again.

I came back to England in 1909 after four years in Australia and got in touch with the Norwegian people, through their agent in London, and I became propaganda lecturer for these new fertilizers to the farmers' clubs and agricultural clubs in south and central England.

At the end of a year they did not send me any more appointments, and I went to see their representative. "Oh," he said, "Scott, we have sold all our output 12 months ahead."

This was the man who represented what is now known as the Norwegian Hydroelectric Saltpetre Co., the one that Mr. Eyde did so much to develop.

So I said, "Well, it is time we began to make it here then." He said, "What do you want to make?"

"Well," I said, "ammonium nitrate, of course; because you are using the ammonia that we send you from England, and for every ton of ammonia that goes to Norway 3 tons of water has to go with it, and it has to be carried in steel tanks, and the steel tanks have to come back empty and take a lot of space on the ships."

Further, there was transportation at Hull and and at Skein, in Norway, and transportation from there on a steamboat to their factory. There the ammonia liquor is merely contacted with the nitric acid, made from the air by the arc process. All you have to regulate is the speed, because of heat given off if it is done too quickly.

The ammonium nitrate made by that process from the ammonia came back to England. So on top of the cost of transporting the ammonia and the water all the way there and transporting the empty tanks back, and so on, there was also the cost of bringing the ammonium nitrate back to England. Obviously then, it would be a good thing to manufacture in England.

"No," he said, "we can not allow you to make any ammonium nitrate in England by our process." And I was not the only man that he said that to, as I found out afterwards. Just what the underlying reason was that they would not let us make nitrate in England with their patents I do not know.

So I set to work, I being then connected with one of the polytechnics in London and having the facilities of electric current and a room to work in. Being an electrical engineer and understanding the difference between the various kinds of electricity, and knowing that the whole tendency of the time would be toward using the 3-phase alternating current in one electric furnace, instead of using the single-phase current in three furnaces, I naturally went at it as an electrical engineer and not as a chemist, to develop a three-phase furnace.

A three-phase furnace is better than three separate single-phase furnaces because there is one apparatus instead of three separate pieces of apparatus requiring separate attention, taking up much more room, and having walls through which more heat can be radiated and therefore lost, and it gives altogether better results electrically.

Then the MacDougalls, Howles, and myself formed a syndicate to develop this furnace. We built a small plant, and when the war started I went, with the permission of my associates, to the war office and offered everything—our knowledge, our patents, everything we had—for nothing.

I managed at last to get to the chief storekeeper at the war office, but he did not know anything at all about nitrates from air and he was sure the war would be over in a few months because we should stop the Germans getting Chile nitrate.

So it went on until about November of that year, 1914, when I was introduced to Lord Moulton. Lord Moulton is a lawyer who has that knowledge of science and engineering which lawyers, who are what we call barristers in England, read up over night. A lawyer has only superficial knowledge.

Lord Moulton was appointed in charge of explosives department. I found he was practically ignorant of the subject of air nitrates. He mixed up cyanamid and the arc process.

Finally I joined the ministry of munitions and had the job of placing by-product niter cake, which is obtained from the manufacture of nitric acid when it is made from Chilean nitrate. Roughly, for every ton of Chilean nitrate that goes into the pots, or retorts, there is rather more, a ton and a quarter, of sulphuric acid added to it. The sulphuric acid drives off from the Chilean nitrate the nitric acid and the sulphuric acid remains behind.

Niter cake is all the sulphuric acid originally put in, plus the soda that is in the sodium nitrate. It has been thrown away in this country, in France, and in my country by the millions of pounds. Numbers of factories all over the world were wasting millions and millions of pounds of this niter cake. My job was to try and get the people who had previously been using sulphuric acid to use niter cake instead. That was because we were relying entirely on sodium nitrate. So it was not merely a question of getting the sodium nitrate by ships across the sea, but also getting sufficient sulphuric acid to treat the nitrate.

Sulphuric acid depends on sulphur, and England had previously always obtained sulphur from southern Italy and from Bilbao, in Spain. So we were badly off from the point of view of sulphur. We had to have men chasing all over the country trying to find iron pyrites with sufficient sulphur in it to be used to make sulphuric acid.

I was called to see Lord Moulton on several occasions. On each occasion I ran into Mr. Barton, who occupies the same position there with the cyanamid company that Mr. Washburn does here. It was eventually arranged with Mr. Barton to put up a plant at Dagenham Dock in Essex.

The CHAIRMAN. Is this cyanamid company in England a separate organization, or has it any connection with this cyanamid company here?

Mr. SCOTT. I think there is some connection. I can not help but feel a certain bitterness toward them, both in England and in this country. Whenever they have had the chance, they have knocked the arc process.

I knew that the arc process was a good process and ahead of the others, in that it made nitric acid direct from the air. Nitric acid is wanted much more than ammonia, because all propellant explosives, T. N. T., cordite, and all the smokeless powders depend on nitric acid, not on ammonia. The ammonia is only wanted for the burster charges.

Perhaps I had better develop that a bit. The burster charge, as we developed it in England, after getting the information from dud shells that the Germans threw over at us, is made of a mixture of T. N. T. and ammonium nitrate—trinitrotoluol and ammonium nitrate. Trinitrotoluol is toluol treated with nitric acid; and ammonium nitrate is a combination of nitric acid and ammonia. The amounts in the burster charges were in one case 78 and 22 per cent, and in another 60 and 40 per cent, the ammonium nitrate being the higher in each case.

Senator WADSWORTH. In that respect your testimony conforms with that of Mr. Washburn, does it not?

Mr. SCOTT. Yes; he said that.

Mr. Barton formed three companies within a few weeks of each other, and his final company directorate was one of the directors of Nobels, which is our big explosive firm in Scotland, and Mr. Albert Vickers, the head of the Vickers firm.

He floated a company for about £2,000,000, and a large part had been distributed and shared out by the time Lord Moulton gave them the order to go ahead at Dagenham Dock.

The companies were watered-stock companies. The patents were nearly run out. The Ostwald patents ran out while the war was on. I knew a great deal about it, and I wrote a letter to the papers, and one of the financial papers in London printed my criticism in part, and another one, the Iron and Coal Trades Review, printed the whole of it.

In the prospectus of this company it was stated that Nobels had given their contract for the ammonium nitrate to this Barton company. So, knowing that Nobels had had a three-year contract with the Norwegian Hydroelectric Saltpetre Co. for all the ammonium nitrate they wanted, made in the way I have just described, I went to their representative and said, "Look here, these folks have taken your contract away from you." "Why," he said, "it was only for one year. We have a written arrangement that after this year we shall go on supplying it."

They were going to make it at a place called Vilworde, near Brussels. The plant never ran as a plant properly, and, of course, when the war came on the Germans took it.

Mr. LANDIS. Mr. Chairman, I would like to take exception to some of these statements that are being made about the cyanamid companies, but I prefer not to interrupt just at this moment, as a matter of courtesy. But it is getting to a point where you are being fed information from a thoroughly unreliable source.

The CHAIRMAN. Just a moment. I think, before the committee would care to hear you on that, we would want to know whether you represent the English cyanamid company or whether that company has any connection with the American Cyanamid Co.?

Mr. LANDIS. I will be very frank to tell you the relationship. The original cyanamid patents were taken out, as mentioned, by two German chemists, Frank and Caro. Those patents passed into the hands of a holding company with a long name, which I could not remember if I cared to. I am personally acquainted with their representatives. The parent holding company has relicensed the rights to use those patents in England, the United States, France, Dalmatia, Italy—there are some 14 or 15 licensees of that company, and the English Cyanamid Co. is just in the same relationship to the original holding company—the Societa, as it is commonly called—as the American Cyanamid Co. is to the Societa.

Every few years all of the cyanamid companies held international conferences, one of which was held in London last summer, which I attended. At those conferences were discussed such matters as the contracts, the trade relationships, the disposition of material throughout the world, and so on.

The CHAIRMAN. In other words, you are all operating under a license?

Mr. LANDIS. All operating under a license from the same head, and we all held technical and commercial conferences during the past few years as political conditions permitted. There was one last summer, at which all the companies were represented, except those in Germany and Japan. The Japanese would have been represented could they have obtained transportation for their representatives. Germany was not invited.

The CHAIRMAN. I think that is sufficient to establish your identity, but I think it is best to let Mr. Scott go on with his statement, and later on, if you wish to comment on it, the committee will be glad to hear whatever comments you wish to make.

Mr. SCOTT. I would like to go on. Mr. Landis's statement simply confirms it. I wanted to establish the connection.

I know this much about it, sir. I was appointed by one of the leading papers in London as the representative of that paper to appear at the first general meeting of that cyanamid company, the Barton Co., after the war began. I was sufficiently in the know to be the man who was selected. I went as an expert.

The Financier and Bullionist, one of our London financial papers, began an attack on this and on Barton personally. That ran for some months and then suddenly ceased, and then later on it came out that the reason was because Barton and his associates had bought the paper and then fired the editor. They dare not bring an action for libel because the statements were all true.

The CHAIRMAN. At the time whom did you represent?

Mr. SCOTT. I was an independent consulting engineer and a lecturer at University College, London.

The CHAIRMAN. You were not in the employ of the Government?

Mr. SCOTT. No; it was before I joined the ministry of munitions. I am bitter against this international group for knocking the arc process every time they possibly could. And no wonder, knowing what I know about what the arc process can do and what I know, about the cyanamid company in England.

Mr. LANDIS. May I interject here? Mr. Scott has just said that the cyanamid interests knock the arc interests. I would like to give you an example of the relationship between the cyanamid interests. There is no relation between the American Cyanamid Co. and the English Cyanamid Co. In fact, we are at odds, and there will be an arbitration to arbitrate our differences, or a court suit to settle those things, coming off before very long. So we are not very friendly.

Further than that, the English Cyanamid Co. has a contract with the Birkeland & Eyde Co. to furnish 25,000 tons of cyanamid as a minimum and 50,000 tons as a maximum each year to the arc process factory for the purpose of converting that cyanamid into ammonia and converting that ammonia further into ammonium nitrate. That does not sound like there was very much antagonism between the English Cyanamid Co., which is the largest of all the cyanamid companies, and the Birkeland & Eyde, or the so-called arc process, when they are working in harmony and furnishing almost two-thirds of the product of the English factory to the arc plant. I visited that plant last summer—in fact, both of them—and became quite familiar with the situation.

Mr. SCOTT. It is true that during the war they found it was difficult to get the ammonia from England over to Norway because of the transportation across the sea. They made an arrangement with the cyanamid company to make cyanamid for them, but they are now getting ammonia from England again. As soon as they could go back to the by-product ammonia, which is cheaper than the cyanamid process could ever make it, they went back to the English ammonia, and they take it over, as I told you, from England to Norway.

Another international group, which has systematically opposed all our nitrate processes, consists of the people who own the officinas down in Chile, those who own the Chile railway and the people who own the shipping to bring that stuff across the seas, also the various factoring companies.

In England those various interests are combined together for propaganda purposes under the name of the Chile nitrate committee. That is legitimate in one way. They are there for the purpose of connecting up these various interests and for putting the qualities of Chile nitrate before the farmers and the other people who use it; but they were continually using their influence, which is extremely powerful—it is about the most powerful trade organization in England—to get into the papers little paragraphs, like "We hear that the Germans are making nitrates from the air, but they can not compete," and

> Nitrate made from the air in Germany has been tried in agriculture and is not any good.

The CHAIRMAN. Then, if I understand you, the Chile nitrate company is really a British company?

Mr. SCOTT. No; there are heaps of companies. The Germans have some officinas down in Chile. It is an international affair, but the British own the railways and, of course, much of the shipping. It is an international group, which has had the Allies by the throat the whole time of the war. They try to keep back the air nitrates. And I am sure you have the same influence at work here.

The CHAIRMAN. Mr. Scott, you may proceed in your own way, but while I happen to think of it, and so that I may not overlook it, I want to ask you this: Would it be possible to manufacture at Muscle Shoals the products which we must necessarily have to put into fertilizer? Of course, I understand that would be a different process, and we could not use the patents which the Government is using now. But I would like, and I think the committee would like, to hear you on whether it would be possible or practicable for the Government to use the process which you are going to speak about, or whether it would be more economical than the process which is being used now. I think that is a very important question.

Mr. SCOTT. The arc process, as a matter of fact, as Mr. Landis has just suggested, is complementary to the other. They are all complementary to one another. I should say that if at Muscle Shoals you are going to confine yourselves to the Haber process of making synthetic ammonia, or the cyanamid process of making cyanamid ammonia, then I do not think you are doing it right. You ought to develop all processes which offer solutions.

The CHAIRMAN. Do you agree with Mr. Washburn that if the Government were to continue to manufacture this product with the process now used it could not be made or manufactured at the prices quoted in this pamphlet which I gave you this morning? You probably saw the prices there.

Mr. SCOTT. He raised a number of points, which I was going to come to later, regarding the working of national factories. I have very strong views on that, which I will tell you. Just at this moment, if I may do so, I would like to refer to a diagram, because it will make my other remarks much clearer.

(The witness here exhibited a chart giving the chemical symbols for the various substances referred to in the hearing.)

Mr. SCOTT. You see, here is ammonia. We use for nitrogen the first letter of the word "nitrogen." For hydrogen we use the first letter of the word "hydrogen." Those two elements are merely combined together in ammonia in the proportion of 1 to 3. So NH_3 is ammonia.

Nitric acid is hydrogen, nitrogen, and oxygen in these proportions, HNO_3.

Ammonium nitrate is simply a combination of these two, NH_4NO_3. You have a plant at Muscle Shoals for making that material, ammonium nitrate.

Now, here is sodium nitrate, or Chile nitrate, and that consists of sodium, nitrogen, and oxygen. As a symbol for sodium we use the first two letters of the Latin word "natrium," so the symbol for sodium nitrate is $NaNO_3$.

And next we have ammonium sulphate, and that consists of sulphuric acid and ammonia, and the symbol is $(NH_4)_2SO_4$.

Now, calcium cyanamid, which is the material made at Muscle Shoals, is a different combination from any of the others. It is a combination of calcium, carbon, and nitrogen, $CaCN_2$.

Nitrate of lime is the fertilizer that was developed in Norway, and is the fertilizer that is used almost exclusively by the Scandinavian farmers, to the extent, I understand, of over 100,000 tons a year, and which before the war went to Germany at the rate of certainly over 100,000 tons a year, to be used by the Germans as fertilizer. That is calcium nitrate, and it is, you see, calcium plus nitric acid, $Ca(NO_3)_2$.

Lime is represented by calcium and oxygen.

Now, I want you to appreciate the difference between these nitric nitrogens and ammonia nitrogens. From the fertilizer point of view it is very important. The plant takes the nitrogen in the form of nitrite or nitrate. If, therefore, you put it into the ground as cyanamid it first of all has to change into urea and ammonia, and then the ammonia has to change into nitric nitrogen before the plant can get hold of it. So cyanamid as a fertilizer is away behind the others, because it has to go through three or four processes to get into the nitric nitrogen stage so the plant can assimilate it. Sodium nitrate, which is Chile nitrate, has the nitrogen in the nitric form and is a good fertilizer. Calcium nitrate is a good fertilizer. Ammonia nitrate is the best fertilizer of them all, because it has the nitric nitrogen plus the ammonia nitrogen, and there are some plants which will do better for having the ammonia nitrogen. For instance, all the paddy fields where the rice is grown are fertilized with ammonia sulphate. It is a good thing there to have the nitrogen in the ammonia form. But for most crops—wheat, cereals, and potatoes, etc.—it is best to have the nitrogen in the nitric form.

We have in England, at a place called Rothamstead, an experiment farm which has been cultivated for several hundred years. It was established by a very wealthy Englishman who was a farmer and had scientific leanings. It is practically a national institution. Experiments with fertilizers have been carried on there for nearly 100 years. They do it very thoroughly. In charge of the researches is Dr. Russell, who is recognized as one of our leading scientific agriculturists. He read a paper last year, which is published in the proceedings of the Society of Chemical Industry, in which he showed that the fertilizer that gave the best results was ammonia nitrate.

The CHAIRMAN. Your claim is then, Mr. Scott, that we ought to manufacture ammonium nitrate and nitrate of lime?

Mr. SCOTT. Why not? When cyanamid is put in with a mixed fertilizer containing phosphates it can not exceed a small amount. The reason is that it causes the phosphate to revert to the insoluble form.

The CHAIRMAN. As I understand you then, it will be possible to manufacture that by the use of the arc process?

Mr. SCOTT. You can make the nitric acid by the arc process and then combine it with the ammonia made by the cyanamid process or the Haber process.

Here is another thing. You have down there the No. 1 plant with the Haber or synthetic ammonia process. Nothing much is being said about that. What has been said has been unkindly said, I think.

Senator WADSWORTH. Well, the Government itself admitted that they made a failure of it.

Mr. SCOTT. Not necessarily made a failure of it. It has been a wonderful success in Germany. It is only a matter of working on it and getting it right.

Senator WADSWORTH. I do not mean they made a failure of it elsewhere; I meant our Government.

Mr. SCOTT. The scientific man is the same all over the world, and I should hate to see this country running down their own people and my country running down its people as compared with Germany. We have in both these countries as good men as they ever had in Germany. Only give them the chance like the German Government did. The German Government developed all these things because they helped their scientific people to do it. They saw that by helping their scientific people to develop methods of fixing nitrogen from the air and being independent of Chile they would have a great advantage.

The CHAIRMAN. Then you claim this is a matter of adjustment: that it is possible to take this plant which has not been successful up to this time, and by proper adjustment, make a success of it?

Mr. SCOTT. Exactly, sir.

The CHAIRMAN. If I understand you correctly, with the process which you are recommending all we would need would be the machinery to extract these substances from the air. Am I right about that?

Mr. SCOTT. To extract the nitric acid from the air direct, yes.

The CHAIRMAN. That would be all that would be required?

Mr. SCOTT. Yes.

The CHAIRMAN. And you need water power to take it out of the air?

Mr. SCOTT. Just power, air, and water. It is the ideal process of fixing nitrogen. It is the way that God Almighty started when he put the lightning to work. Every lightning stroke forms nitric acid: when the water comes down as rain it brings that fertilizer down. You will often notice how beautiful the vegetation is after a thunderstorm; it is partly due to fertilizer that has been formed by the lightning.

The CHAIRMAN. As a practical proposition, would it be possible to make these compounds of which you are speaking, using these plants, and meet the competition of the other processes as to price?

Mr. SCOTT. Yes, sir; because the prices which they are talking about as being the rates at which you are going to generate power at those dams on the Tennessee River are well within the point at which we can make it economically by the arc process. I will quote you some figures directly that will demonstrate that.

Now, the air consists of the two gases, oxygen and nitrogen. Water consists of hydrogen and oxygen. Nitric acid, of course, consists of hydrogen, oxygen, and nitrogen, these three joined together.

And the nitric acid is wanted most if you go to war again—nitric acid first and ammonia second. The best way to make nitric acid is direct from the air.

The way in which it was proposed to make nitric acid at Muscle Shoals was to take half of the ammonia and pass it with air over a catalyst, which catalyst has to be platinum. You will remember the predicament we were in for platinum during the war; it was required for making nitric acid and sulphuric acid. The Government managed to get a big consignment of platinum from the Ural Mountains in Russia before the Germans got in there. The first thing the Germans did when they got into Russia was to corner platinum. That is one of the things they were aiming at.

By a platinum catalyst ammonia can be changed into nitric acid, but it is only a war measure. The price of any nitrogen product is governed by the price of the unit nitrogen. Therefore, if you take ammonia in which the price of the unit nitrogen is X, and change that by a complicated process and the use of this expensive metal platinum, into nitric acid, in which the price of the nitrogen is also X, there is no sense in it. As a peace measure, changing the ammonia into nitric acid is impracticable, because it is uncommercial.

But the plant may be kept there against the next war in case you do want to make it that way. But I hope that by the time you enter another war there will be arc plants in operation.

Senator KENDRICK. You evidently have the idea then, Mr. Scott, that I suggested this morning, that this whole system will prove to be one of evolution?

Mr. SCOTT. Of course, sir. No one knows which is the best to-day, and whichever was the best to-day would not necessarily be best next year.

Senator KENDRICK. It would be obsolete within a few years?

Mr. SCOTT. Not necessarily obsolete, but changed. There will be improvements brought in. As I say, sir, these processes are complementary to each other. And the position of each of us in trying to knock the others ought to stop, and I am prepared to stop it. I knock because they knock, and I am a lone hand in this country.

You are a farmer, are you not, Senator?

Senator KENDRICK. I am.

Mr. SCOTT. An agricultural company in New York sent for me to come in one day, and they said, "We hear this nitrate of lime can not be used as a fertilizer." Why, they have been generating electric power in Norway for years up to nearly 300,000 kilowatts, and that is what they made. It had to go into the ground somewhere, and some went to Germany. A good deal came to England. Some of it went to California and was used there by the citrus growers, and it is going there now. Some of it went to Honolulu before the war.

When Mr. Washburn said it can not be used—you remember I said, "You know it can be used," and then he said yes, he did know. Of course he knew. There is no other use for it but as a fertilizer, and nitrate of lime and ammonium nitrate are two of the fertilizers you can make at Muscle Shoals by the arc process.

The fertilizer merchants in England or elsewhere simply put calcium nitrate from Norway in place of the sodium nitrate, and the farmers did not know the difference. Why should they know?

It did not matter to them whether it was sodium nitrate or calcium nitrate, and the latter was better for them, of course, because it left lime in the soil instead of soda.

When the refugees came over from Belgium and France we settled them in our villages in England and gave them plots of land to cultivate. Nearly every one of them was an expert gardener, and they showed our people how to garden and one fertilizer they asked for was ammonium nitrate. When ammonia nitrogen has done its work it only leaves water in the soil, and therefore you can keep on using it because you are only adding water. But if you put sodium nitrate in the soil continuously you have to give the soil a rest, and if you put sulphate of ammonia in the soil you have to give it a rest; otherwise you will put so much sulphuric acid into the soil that you can not grow anything. But when you put ammonium nitrite into the soil you are adding something that has in it 35 per cent of nitrogen, a higher percentage than all the others, and therefore it takes less work to add it. It can also be transported for less cost because of the high percentage nitrogen content.

Senator WADSWORTH. What does the Government mean here in their estimates as to the output of this plant and the costs per ton as to the three different classes of output? What do they mean by the term "nitrate"? Nitrate of what, as contrasted with sulphate or cyanamid?

Col. BURNS. It is the same thing, Senator. Ammonium nitrate is meant, the very thing Mr. Scott is talking about.

Senator WADSWORTH. I am afraid to ask you this next question: that is, I am afraid for myself, not for you. It seems to me, judging from these figures, that the Government has the cart before the horse on what they ought to do down there. They propose to make 107,000 tons of sulphate of ammonia annually and 22,000 tons of nitrate. The sulphate of ammonia, as I understand it, can not be used indefinitely without leaving too large a deposit of sulphuric acid in the soil.

Mr. SCOTT. Yes; that is the fault of that compound. Of course, a lot of farmers are accustomed to use it, and they have to be brought to see the advantage of the newer fertilizers, but that is only a matter of propaganda by the Agricultural Department.

Senator KENDRICK. Is it your purpose before you finish, Mr. Scott, to give some opinions on their equipment down at Muscle Shoals for the production of these different compounds?

Mr. SCOTT. Yes; I can do that; but I do not want to appear here as boosting my own particular furnace. I want to boost the arc process as a general process and show that it is complementary to what you have got there already.

New men coming into this game can do as well as the older men. I am in the arc rut. Mr. Landis is in the cyanamid rut, and Dr. Parsons is in the synthetic-ammonia rut. Financial people say: "You have got to boost this particular thing." But I am through with all that now. There are sure to be a number of processes come out, and you want to try them all, and you want a national factory to do it. You have some bright and alert men in the Nitrate Division, and they can put it over, and they can run Muscle Shoals just as well as any private company can do it.

The arc process makes sodium nitrite. It is the nitrogen compound that is wanted for the dye industry. There is a factory in Seattle making it. After all the talk about the other processes, the only one actually running is an arc process and making large profits. They are putting up another plant like it in British Columbia.

Senator WADSWORTH. What is the source of their power?

Mr. SCOTT. Water.

Senator WADSWORTH. At Seattle?

Mr. SCOTT. Yes; and in British Columbia also. They are sending most of their output to Japan, and the Japanese are using it for making dyestuffs. American dye makers are getting sodium nitrite from Norway, where it is made from the air. The Badische Anilin & Soda Fabrik, of Germany, depended on sodium nitrite for making many dyes, and they made 80 per cent of all the dyestuffs in the world before the war. When they investigated the arc process they found it was so much better than any other that they established in Norway a plant for making sodium nitrite.

This is a material which you can also make at Muscle Shoals. It happens that nearly all chemical factories make some by-products. The by-product of the arc process is sodium nitrite nitrate, a mixture. From that you can make the nitrite for the dyestuffs. Sodium nitrite has about 20 per cent of nitrogen in it, may possibly be used as a fertilizer. That is one of the things that has got to be found out by the research laboratories and the agricultural colleges.

There are certain by-products of every chemical process. The by-products of the cyanamid processes are oxygen. Why? Because they make the pure nitrogen which is necessary for the cyanamid process by liquefying air. They make nitrogen of 99.5 per cent purity, but they also get the remaining gas, which is oxygen, as an impure gas, about 55 or 60 per cent purity.

Now, that gas as Muscle Shoals is going to be thrown away. Why? Because to get it in a salable condition it would have to be purified up to 99.5 per cent. It would then have to be compressed and put into those long steel bottles, and then, of course, there is the carriage of the bottles to various places where you could use the gas. Further, they are obliged by the contract with the makers of the liquid-air plant not to sell the oxygen. But they can give it away.

Now, the arc process depends on the action of the electric arc on air. Air consists of 79 per cent of nitrogen and 21 per cent of oxygen; that is to say, there is four times as much nitrogen as oxygen. What we are going to do in the arc furnace is to oxidize the nitrogen. Now, you know if you are going to oxidize anything it will rust quicker if you put it into oxygen than if you put it into air. Therefore, if we can blow through the arcs air plus oxygen, which oxygen is being given by a company next door, we can increase the yield, and the yield may go up anywhere up to 20 per cent. If they can not use the oxygen, you might as well have it from them. And if you can do that and increase the yield of the arc process, so much the better for having an arc process next to the cyanamid plant.

The cyanamid plant also depends on lime for making the carbide. When you grind up the limestone you naturally make a lot of powdered lime, and that can not be fed into the furnace, so it has to be thrown away. But that lime is the very stuff we want for making nitrite of lime, and the fact that it is in a powdered state, a state in which the cyanamid people can not use it, makes it the very thing we want. It is, therefore, the second by-product we can make use of by the arc process.

Further, in making ammonia from the cyanamid they do it by putting the cyanamid into autoclaves and treating it with superheated steam. They put the cyanamid, $CaCN_2$, into the autoclaves, and they add to it water in the form of superheated steam, H_2O. The hydrogen of the water seizes on the nitrogen and forms ammonia gas, and that comes off; but it leaves behind a lot of slurry that is lime. There is a third by-product which can be used up by the arc process.

A great deal of the expenditure at nitrate plant No. 2 went into an absorption-tower plant. If the cyanamid plant is run to make ammonia, these towers are not wanted, but for an arc plant they are just the thing. Towers are the largest item of cost in an arc plant.

I strongly advocate going ahead with this Muscle Shoals plant, if it were for no other purpose than for war purposes; there are heaps of reasons why you should do it.

Do not get caught again depending on Chile nitrate. Be sensible and do not get caught again depending on ships. You will want 48 ships at least to bring Chile nitrate continuously. There is a bill going through just now, of which I have particulars here. You will probably recognize it. It is a bill to get the farmers some nitrate of soda, and it is to come from the Army; the Army is having to give up some of its stock of nitrate of soda. The farmers want it just now, because it is spring. Why is this done? Because the Culebra Cut is blocked. Now, if it is possible for that cut to be blocked by a landslide at this time, what is to prevent somebody in the next war dropping bombs there and stopping up the canal for a year? Then you would have to get all of your Chile nitrate by way of San Francisco. Do not get into that position; run the plant as a war measure.

Our Woolwich arsenal in England never did pay; everybody knows that. And the Enfield small arms arsenal in the north of London never paid. But we keep them going, and do it in order to be ready for war. We have other factories run by the Government. An armament factory in Australia was established when I was there. There was never any question of its being established by private capital. The Government took land in the Blue Mountains, well away from the sea, and put the plant up there.

You have got to have some Government plants, because you want trained personnel and you want the nucleus to establish other plants in case of war. You must run the Muscle Shoals plant so as to have men ready, with experience, who can immediately train other men.

Another thing: You want in peace times to have a balancing factory for the fertilizer business. There is no question about it, that the fertilizer business is in the hands of a small group of big financial people, and they have got the farmers, and the rest of the country through the farmers, by the throat. A lot of the tankage stuff they sell is, as Mr. Washburn said, not up to much. It would be a good thing to have a balancing factory, to keep those people in hand. For making fertilizer until the next war comes, it will probably pay its way; but if it does not, run it all the same.

Senator WADSWORTH. At a loss?

Mr. SCOTT. At a loss; yes. Woolwich Arsenal has been run at a loss for the last 100 years.

Senator WADSWORTH. But they were not turning out a commercial product; they were turning out things for the Government.

Mr. SCOTT. Yes; that is true.

Another thing: You want this plant to be run, because the world will not stand still. Some of the most alert minds in the world are engaged on this nitrogen fixation business. The very fact that many people have made fortunes in it has made others get busy. And a lot of people are in it like I am, because they are interested scientifically. You want some place to try inventions out.

The CHAIRMAN. Have you any idea what royalty the Government would have to pay if they were to use the arc process?

Mr. SCOTT. About the time the war came to an end the Government invited Mr. Liljenroth, of the DuPont Co., to the Nitrate Division. He was formerly consulting engineer to the Norwegian Hydroelectric Saltpetre Co., and a very able man. He was there for nearly a year, I think, and he had a large staff of assistants. He got out for the Government a complete set of plans for an arc process plant like they have in Norway, and all you have to do is to erect that plant, or, say, half of it.

Then let me suggest this. When anybody comes along with an arc furnace that has some promise to it, let Dr. Lamb, or Col. Burns, and other trained engineers pass on it. If thought good enough, let it be tried out in your research laboratory and afterwards at Muscle Shoals. In that way you will gradually acquire a great mass of valuable information.

The CHAIRMAN. Of course these processes are patented, just like the cyanamid process?

Mr. SCOTT. Yes.

The CHAIRMAN. And we would have to pay a royalty?

Mr. SCOTT. Yes, unless the patents should run out. The Birkeland and Eyde furnace patent ran out last year. I believe the cyanamid patents of Frank and Caro are out now in America. I am not sure; Mr. Landis can tell you. Of course there are detail patents which will probably carry them on for a while. But if you have to pay the royalties, why not, so long as the true inventor gets the reward. Inventors are the most worthy and the most unfairly exploited class in the community. Having the aid of the Government would probably suggest to some that they should not press any question of royalty.

The CHAIRMAN. Would it be as difficult, or more difficult, for the farmers to mix fertilizer with the compounds produced by the arc process?

Mr. SCOTT. No, sir; it would not be any more difficult. There is a condition that comes in here which we call deliquescence. Some materials in the impure state are more deliquescent than they are in the pure state, and some materials in the pure state are more deliquescent than in the impure state. A standard of deliquescence is this nitrate of soda; it is good from that point of view. Basic nitrate of lime, which has excess lime, in which the particles are in the granular form and from which all fine powdery stuff has been taken out, will do as well as the sodium nitrate.

The British Government, while I was in the service, investigated the deliquescence of the ammonium nitrate, and in a particular crystalline form its deliquescence is lower than that of the sodium nitrate from Chile. But if it is left for a long time it changes its crystalline form and becomes rather more deliquescent than sodium nitrate. Nearly all these materials can not be kept very long; not for years, I mean; they have to be used within a fairly short period after they are made.

But there is no reason why this sodium nitrate should come from Chile. It is made by the arc process in Norway in considerable quantities and is sold to explosives and chemical manufacturers in England in preference to the Chile product because of its great purity.

I understand the idea in this country and every other country is that we are going to be independent of Chile when the next war comes along. But, of course, that has got to grow gradually. It will be some years before any country can be independent of Chile, but whether we like it or not every country has got to be, because it is only a question of years before Chile nitrate deposits will give out, probably not beyond the next 50 years.

Speaking of patents, I had brought to my notice the other day a patent taken out by a Mr. Wilmowski, of Boston, who is now dead. He had assigned the patent to Edward J. Prindle, of East Orange, N. J., and he is the assignor to the Norwegian Hydroelectric Saltpetre Co., a corporation of Norway. This appears to be a patent which is being held for the purposes of litigation. It was applied for October 28, 1896, serial No. 610286. It was not granted and printed until April 18, 1914. It was in your Patent Office for 18 years.

Patent lawyers who understand the system send in a patent specification which they know the examiners in the Patent Office will not allow. They deliberately make a mistake. They are allowed, I think, 12 months to put it right. They then send it back with more mistakes, and that goes on for 18 years. In the meantime the art is growing up. Even the inventor dies. Then the patent is printed.

This particular patent does not mention anything about nitrates from air, and if there is any justice in this country I hope to goodness they will never allow that thing to be used as a hammer on this air-nitrate industry. But there it is. It has been allowed within the last few years, and it may be brought forward some day if there should be a lawsuit.

This holding of patents for a long time by the Patent Office and the buying of patents and then not exploiting them is absolutely wrong. Some countries will not allow patents to be bought by any person or corporation and then not utilized. I do not know whether that is useful information.

The **Chairman**. Personally I think it is a good suggestion.

Mr. **Scott**. I have here the final report of the nitrogen products committee of the British ministry of munitions. This is the most complete that I have seen on the air nitrogen business. Before this was published the most complete was one that your Government got out, "The Utilization of Atmospheric Nitrogen," by Thomas H. Norton, Special Agents Series 52, of the Department of Commerce and Labor. Scientific people were very grateful to the United States Government for giving that out.

The information that he got together was extremely useful to all of us. And now I think we in England have put the world in our debt by publishing this in the same way. There are some things in this which I do not agree with, but generally it is a most valuable document.

It is recommended that in Great Britain they should immediately establish the two processes which you have got down at Muscle Shoals.

Senator Wadsworth. Which two?

Mr. Scott. The cyanamid plant and the Haber plant. But there are indications right through the document that the committee was extremely favorable to the arc process, and that if we had had cheap power in England they would have recommended the arc process. The report says:

> In many other parts of the British Empire, where cheap water power is being or could be developed—for example, in New Zealand, Tasmania, Egypt, and India—the manufacture of synthetic-nitrogen products could be profitably undertaken.

And there are indications elsewhere in the book that where there is cheap electric power it will be done by the arc process.

Senator Wadsworth. Do you think we have cheap enough power at Muscle Shoals for that?

Mr. Scott. When I asked Mr. Roberts about that the other day he spoke of power being $10 per horsepower year. If that is true, that is cheap enough. That was the figure that Mr. Washburn gave as the average price of power in Norway. There have been some remarkably low figures given for water power in Norway, but they do not always include depreciation and other items which we are accustomed to put in. Very low prices are also quoted at which one company sold the power to itself; so they could put it in at any figure they wished. Ten dollars a horsepower year is cheap and quite feasible for the arc process. As a matter of fact, it is feasible at $20.

To give you an idea of prices and how that price compares with others, I have had a quotation fairly recently from a hydroelectric company up in Maine of $14. The price at which the Ontario hydroelectric commission is selling it to the cyanamid company, I believe, under a very old contract, is somewhere under $11. The price at which they are selling it in large blocks to people within a reasonable distance of of Niagara Falls is a little over. So the figure of $10 for Muscle Shoals seems to be about right. You may do it cheaper than that.

Senator Wadsworth. How much power should they have in order to use that arc process economically?

Mr. Scott. Ten thousand kilowatts—12,000 horsepower. And you are going to develop very much more than that. But as I understand this proposition regarding the development of power down at Muscle

Shoals, you are doing it for several purposes. You are putting in those dams, first of all, in order to enable the Tennessee River to be navigated by large boats.

Senator WADSWORTH. Well, if I may express my opinion, that is largely camouflage.

Mr. SCOTT. Well, if it were going to do any good to the Tennessee River and enable the transportation of materials more easily than is now done by the railways it would be a good thing, even if it did not develop any power. But if you are building dams merely to develop power, I also say go ahead, because that part of the country needs developing.

At a dinner given to the American Electro-Chemical Society when they made a trip to Chattanooga and Muscle Shoals—after they told me what they found there and named nearly all the minerals there were, I said, "Well, it is the jewel box of America." And it is. Why, it is a wonderful district. It is all that Mr. Washburn said it was in 1916. It wants developing, and the only way to develop industries nowadays is by cheap electric power. The steam engine has gone forever, and if you can get the power from those dams and use it for no other purpose than to develop the country, it should be done.

A large part of this book is concerned with the establishment of big super-power stations which we are going to build over there in England. The Government are building them—not private enterprise. There are something like 16 of them in the program, and I think they have got three or four already started.

The CHAIRMAN. They are building them now?

Mr. SCOTT. Yes; big steam power stations. The whole of England is going to be run electrically.

Senator WADSWORTH. Are they putting them near the coal mines?

Mr. SCOTT. They will be arranged in convenient places where there is both coal and water. They are going to be placed in different parts of the country and connected up by transmission lines, which are to be run along the railway systems. Eventually the railways will all be electrified.

On page 29 the report says:

"The minimum scale of steam-power station for operating the arc process to the best advantage under British conditions is thus determined by the minimum cost of generating electrical energy from coal. From the point of view of the home nitric acid industry, however, it is worthy of note that the arc process, if operated on a scale of from 15,000 to 20,000 kilowatts could produce concentrated (93 to 96 per cent) nitric acid at a lower cost than the standard retort process using Chile nitrate as long as the cost of electrical energy did not exceed £9 per kilowatt year."

Nine pounds is over $40, but you are going to make it for $10 down here. We could use the arc process in England, using coal, with all the labor that that requires. When you go into a water-power plant it is difficult to find anybody in it, but in a steam plant you have to have men all over the place. There are all sorts of things to go wrong. And yet we can make acid by the arc process in England with power at over $40 a kilowatt-year at a cheaper rate than it can be made from Chile nitrate.

And these are very conservative estimates. The nitrogen products committee obtained information from all over the world on this subject, and they particularly got all the information the Norwegians could give them, because Norway in the war was very closely associated with the Allies.

The CHAIRMAN. Who owns the patents for the arc process in Norway now? Is it the Birkeland & Eyde Co.?

Mr. SCOTT. Yes, sir; but I believe they have about run out. I know the main patent has run out in Canada, but of course there are detail patents.

The CHAIRMAN. Have they a patent here in this country for the arc process?

Mr. SCOTT. Yes; the original Birkeland Eyde furnace patents in America are 13240 and 13280 of 1902.

The CHAIRMAN. Of course these patents are a good deal like the charter of a national bank; it runs out, but there is a moral obligation which has to be taken into consideration.

I am very much interested in your statement with reference to what is proposed to be done in England. Out where I live we have 15,000,000 acres underlaid with coal, where we can scoop it up with steam shovels, where you can strip the soil off and simply use shovels to pour in seven tons a minute with one shovel. We have done that, so it is not an estimate. I was asking the Government experts who were here the other night if we located a plant, say on the Missouri River, which is quite a large body of water, where we have all this abundance of coal and all we have to do is simply to scoop it up, whether it would not be possible for us to manufacture our own nitrates in that country.

Mr. SCOTT. Yes. If you have coal like that, so easily obtained, and a good river you could probably manufacture your electricity there at about the rate at which it could be made at the hydroelectric dam. As Mr. Washburn said, of course, the first cost of putting in hydroelectric power is very high, much higher than with steam, but after it is in you do not have to pay anything for fuel. You are using white coal, which costs nothing.

I just want to take up the question as to whether it would be useful to have the dams from the navigation point of view. I was in Chicago when I received your telegram, seeing Mr. Luther V. Rice, consulting engineer of one of the largest consulting engineer firms in the world—Robert W. Hunt Co. They have designed and erected many big steel plants and are interested in iron and coal particularly.

Mr. Rice has just returned from a trip in Alabama, extending over several months. He told me the following:

He has reported on 150,000 acres of iron ore and coal lands which are on the upper Tennessee River, and which will be developed by Chicago and St. Louis capital if the water transportation of the Tennessee River is improved by the building of the Muscle Shoals dam. These coal lands are in Marshall, Etowah, and Dekalb Counties. They lie between Guntersville and Gadsden. There are 20,000 tons of iron ore of the red Clinton hematite quality on each of the 150,000 acres. Also, there are 9,000 tons of coking coal upon each acre, all of which will be made available by the building of those dams. The iron ore and coal will be brought by water to St. Louis, and then on to Chicago after the completion of some canals which are now being built across the country between those two cities.

The situation as he sees it, regarding the power dam, is that an enormous amount of money has been spent, or misspent, as you prefer, but it will all be thrown away unless further money is put up to finish the job. I suggest that you might call Mr. Rice.

The **Chairman**. Can you give us his address?

Mr. **Scott**. Mr. Luther V. Rice, of the Robert W. Hunt Co., Chicago.

The **Chairman**. It is evident you can not finish to-day, Mr. Scott. It is a little early for farmers to quit, but as I know you are tired we will take a recess now until Monday.

(Thereupon, at 5.05 o'clock p. m., the committee adjourned to meet at 10.30 o'clock a. m. Monday, April 12, 1920.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

MONDAY, APRIL 12, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

The committee met, pursuant to adjournment, in room 326, Senate Office Building, at 10 o'clock a. m., Senator Asle J. Gronna, presiding.

Present: Senators Gronna, McNary, Kendricks, and Harrison.

The Chairman. You may proceed, Prof. Scott.

STATEMENT OF MR. ERNEST KILBURN SCOTT—Resumed.

Mr. Scott. This is the final report of the nitrogen products committee of the British ministry of munitions of war. [Exhibiting volume to the committee.] It is such an extremely valuable document and is so voluminous, covering as it does 360 pages, that it occurred to me that it would be useful in the record of the hearings to have some extracts from it, particularly bearing on that side of the matter which I am trying to present.

I want you to have a very clear idea as to the personnel of this committee. There are 24 members, a large number of whom I know personally, and I want to say that most of the gentlemen on this committee are of eminent scientific attainments, either scientists pure and simple, or professors, or connected with the industry as consulting engineers or manufacturers. The chairman, Col. Sir Henry Goold-Adams, is a military man, in the Artillery, and with engineering ability.

There are representatives on this committee of Physical Society, the Chemical Society, the board of agriculture, the explosives department of the ministry of munitions, the board of trade, the nitrogen research laboratory, which is our equivalent in England to what you are doing at the American University; the Faraday Society, which is our equivalent in England of your American Electro-Chemical Society, and which is affiliated with it. (We use the name "Faraday" because he was the father of the dynamo and all electro-chemical work.) There is also a member of the electric supply committee of the board of trade. Six of these gentlemen are professors and six are consulting engineers, and only two of them can be said to have real direct interest with manufacture. There are no members of Parliament. Two are lawyers.

Senator Kendrick. Mr. Chairman, I would like to ask Mr. Scott this: Is it your intention to give us a detailed list of such references as ought to be included in our record?

Mr. Scott. Yes, and I will hand them as I read them to the reporter, and you can follow the research, if you wish, in the book.

The Chairman. I think it will be very desirable to get the information. We might also include the names of the men without reading them all.

(The names of the British committee referred to as directed by the chairman to be inserted in the record, are here printed in full, with description of their various professions:)

Col. Sir Henry E. F. Goold-Adams, K. B. E., C. M. G. R. A. (chairman), military.

G. S. Albright, Esq., M. A., consulting engineer.

W. R. Bousfield, Esq., K. C., M. A., F. R. S., lawyer.

Charles C. Carpenter, Esq., D. Sc., M. Inst. C. E., scientist.

Kenneth M. Chance, Esq., M. A. (co-opted), chemical manufacturer.

Prof. J. Norman Collie, Ph. D., D. Sc., LL. D., F. R. S., scientist.

W. R. Cooper, Esq., M. A., B. Sc., M. I. E. E., representing the physical society. Editor.

Lieut. Col. A. W. Crossley, C. M. G., D. Sc., F. C. S., F. R. S., representing the chemical society. Prof. of chemistry.

Sir James J. Dobbie, M. A., LL. D., D. Sc., F. R. S., representing the board of agriculture and fisheries.

Prof. F. G. Donnan, M. A., Ph. D., F. R. S. Prof. of chemistry.

Sir Arthur Duckham, K. C. B., M. Inst. C. E. Consulting chemical engineer.

R. C. Farmer, Esq., O. B. E., Ph. D., D. Sc., representing the explosives department. Chemist.

F. Gossling, Esq., B. Sc., representing the board of trade. Scientist.

J. A. Harker, Esq., O. B. E., D. Sc., F. R. S., director of nitrogen research laboratory. Scientist.

Prof. A. K. Huntington, A. R. S. M., M. I. M. M., M. I. M., representing the Faraday Society. Prof. of chemistry.

F. H. Jones, Esq., M. Inst. C. E. (co-opted). Consulting chemical engineer.

C. H. Mertz, Esq., M. Inst. C. E., M. I. E. E. (co-opted). Consulting engineer.

Right Hon. Lord Moulton of Bank, G. B. E., K. C. B., M. A., LL. D., F. R. S., director general of explosives supply. Lawyer.

J. H. Rider, Esq., M. Inst. C. E., M. I. Mech. E., M. I. E. E. (co-opted). Consulting electrical engineer.

E. J. Russell, Esq., O. B. E., D. Sc., F. R. S. Prof. of engineering.

Sir John F. C. Snell, M. Inst. C. E., M. I. Mech E., M. I. E. E., representing the Institution of Electrical Engineers. Consulting electrical engineer.

Prof. the Hon. R. J. Strutt, M. A., F. R. S. Prof. of chemistry.

Sir Richard Threfall, K. B. E., M. A., F. R. S. Scientist.

A. J. Walter, Esq., K. C., M. A., LL. B., representative of the ministry of munitions upon the electrical power supply committee of the board of trade. Lawyer.

Mr. Scott. You, sir, asked me whether the quotation I have read applied to prewar conditions?

The Chairman. Yes.

Mr. Scott. Every financial statement in this book refers to prewar prices. Any arguments, therefore, that I bring forward will be all the stronger to have read into them present prices.

For instance, in paragraph 31, page 7, there is the following [reading]:

> The committee has deliberately adopted prewar conditions as th only satisfactory basis for dealing with the question of costs and prices, since it is obvious that the constant fluctuations in the rate of wages and prices of materials during the war period render it impossible to arrive at a true comparison of estimates based upon war conditions. This has led to some difficulty in the case of a process like the ammonia-oxidation process, which owes its expensive commercial adoption entirely to the war demand for nitric acid, but guidance has been afforded in such a case by manufacturing experiences with processes of an analogous character.

So many conflicting statements have been made from time to time regarding the cost of making nitrates from air by the various processes that it is a positive relief to be able to turn to this book, because it is such a very authoritative document. I feel that this record will be accepted universally by all people, the Germans included, because we centralized in London all the information that it was possible to get. All engineers and scientists on the allied side pooled their knowledge, and, as you know, the world made a tremendous stride ahead in inventions and in the application of inventions because of that pooling of knowledge.

The CHAIRMAN. And the scientific men of the allied countries agree upon this one document?

Mr. SCOTT. A few of them might pick holes in statements, but generally say that is something we can practically all agree on.

I propose first to make some references to the arc process, and in paragraph 197, on page 46, there is the following, under the heading "Power requirements and output of product" [reading]:

> After a careful examination of the evidence as to the power requirements the committee has come to the conclusion that when full allowance is made for losses during the absorption and concentration stages, the final output of marketable products expressed as the equivalent of 100 per cent nitric acid will amount to a minimum of 535 kilograms HNO_3 per kilowatt year of 8,760 hours, measured at the station switchboard, or 61 gm. of HNO_3 per kilowatt hour. The consumption of energy thus amounts to 1.87 kilowatt years per metric ton of HNO_3 (calculated as 100 per cent), or to 5.41 kilowatt years, per metric ton of fixed nitrogen recovered. These are reasonable grounds for believing that with modern, large-scale electric furnaces the yield might be about 10 to 15 per cent higher and the power requirements thus correspondingly smaller, but the committee has advisedly adopted a conservative figure that can be safely realized in ordinary working practice.

The CHAIRMAN. You are speaking now of the arc process?

Mr. SCOTT. Yes.

Senator KENDRICK. I think what you said referred to either process, did it not, Mr. Scott?

Mr. SCOTT. The methods of measuring do, for we always talk of nitric acid in calculations as of 100 per cent. There is no such thing as 100 per cent nitric acid; we can not get it, and we would not want it if we could get it; 93 to 96 per cent is as high as we ever want. But we always refer to 100 per cent nitric acid so as to have a common basis when talking about these matters.

The CHAIRMAN. As you go along you will probably discuss, if not in detail, briefly, the merit of the arc process and the amount of compound manufactured by the various countries. As I understood Mr. Washburn, it was his understanding that a very small amount of these nitrogenous compounds are being produced at the present time by the arc process?

Mr. SCOTT. Yes, sir. There are figures in paragraph 201, page 46, which says [reading]:

> Notwithstanding the handicaps, the arc process, with electrical energy at 3.75 pounds per kilowatt year could produce concentrated (93 to 96 per cent) nitric acid at a cost at the factory of 11.5 pounds per metric ton of HNO_3 (calculated at 100 per cent), or about half the cost of the Chile nitrate retort process, namely, 22.3 per metric ton of HNO_3. For every additional pound 1 per kilowatt year in the cost of electrical energy the production costs by the arc process would be increased by 1.87 pounds per metric ton HNO_3. (Appendix V, sec. 3, and Chart A.) As long as the cost energy is below 9 pounds per

kilowatt year, the process—even when allowance is made for interest at the rate of 5 per cent upon the heavy capital cost of the arc-furnace installation—would stand to advantage as compared with the retort process. The production cost of concentrated acid at a very favorable water-power site would be about 6.7 pounds per metric ton HNO_3, or 40 per cent less than at a large factory operating with steam-generated power in this country.

The CHAIRMAN. That is really what they would have to do in England, is it not, use steam, because they would not have water power?

Mr. SCOTT. Yes; they will have to rely upon steam power in England, but it is probable that arc processes will be developed where there is water power, and particularly in Canada, Tasmania, New Zealand, Australia, and India.

If at the beginning of the war we had established the air nitrate processes in Great Britain we would have saved much shipping, and we would have kept the money, like Germany did, to use for other purposes. We would have saved a great deal of that trouble through the submarine menace because we had to put boats on the Chile nitrate trade which would otherwise have been employed in carrying troops or food across the sea, and warships had to be detailed to protect the nitrate boats. We could also have made the acid for one-fourth what it cost to make it from Chilean nitrate.

The CHAIRMAN. Of course, the thing of greatest importance would be that they would be absolutely sure that they would have it; they would not have to depend on any other country; they would not have to depend upon shipping; they would have it at their own door, you might say?

Mr. SCOTT. Yes.

The CHAIRMAN. And, as I understand it, they would have it cheaper than they could possibly get it through the purchase of the Chilean nitrate?

Mr. SCOTT. Who put this over on the Allies, and particularly the British? The Chilean group of nitrate financiers. The head of our Explosives Committee on the Ministry of Munitions was Lord Moulton, a very old gentleman who had made a name for himself as an attorney, a barrister, as we call them in patent cases. He had the knowledge of scientific matters which the barrister gets by reading briefs, etc., over night; he does not have time to do it any more thoroughly than that. Lord Moulton was essentially a lawyer of the same political faith or Lloyd-George, and Mr. Lloyd-George—I am not criticizing this—surrounded himself with men of his own political faith like your own Mr. Wilson does. But Lord Moulton was in an advanced stage of senile decay. He could not keep his head still; he could not tackle the problems that arose. He was put in there partly because of his record as a patent lawyer and partly because of his political connection. But he was kept in there by people who did not want any air nitrate processes started in England.

The explosives department was running over with chemists whose knowledge of nitrates was the old-fashioned Chili nitrate process. There was no one who could talk authoritatively about air nitrates.

The CHAIRMAN. As I understand it, Prof. Scott, you had no trouble with this Norwegian Government; that is, you had no trouble in getting their cooperation and obtaining anything they had in the way of either scientific knowledge or whatever quantity they might have of those compounds?

Mr. SCOTT. After the war had been going on for some time, I remember quite well seeing Dr. Hodgkinson, the professor of chemistry at the Woolwich Arsenal, who taught chemistry to the young officers and probably some of the staff. He was a member of the first explosives committee. About January, I think it would be, 1915, when the war had been going on about five months, he told me that he was going up into the north of England to investigate where our ammonia was going to; that we were not getting back from Norway the ammonium nitrate which should have been made from that amount of ammonia we were sending over there.

The British and the French Governments and the Norwegian Government, which has always been friendly to us, got their heads together, and they stopped any more of that material going to where it was going.

And they made an arrangement that whereby the whole of the output from Norway came to England from then on. The reason, perhaps, why the Allies were enabled to fix up this arrangement with the Norwegian Government easily was that so large an amount of French money was in the Norwegian arc process—French banks—practically financed it.

Senator KENDRICK. Was it not something of a breach of neutrality to agree to deliver all of such a product to one of the contending forces?

Mr. SCOTT. It may have been. I believe some pressure was brought to bear on the Norwegians by the food conditions. We took all their fish and distributed it, and then we let them have wheat and other foodstuffs which they could not grow in sufficient quantities. They began to grow larger quantities afterwards.

At the end of this first portion of the report these are the observations and conclusions, and in paragraph 605 they give the following, as I think, momentous statement. [Reading:]

> The committee is satisfied, however, that at a really favorable water-power site nitric and nitrate nitrogen can be produced more cheaply by the arc process than by any other method.

Senator MCNARY. I thought our testimony here given some weeks ago showed that the Haber process was by far the cheapest of the different processes. You have just contradicted that statement?

Mr. SCOTT. Yes; they had the Haber process information when they put this into print.

Senator MCNARY. As I recall it, speaking now from memory—I have not attended these hearings on account of conflicting dates for hearings on the Shipping Board matter before the Commerce Committee—the Haber process was not generally known by the Allies, but it was thought that Germany had perfected that plan, had worked it out very much cheaper than any device known to the Allies or any of us. This seems to contradict that statement?

Mr. SCOTT. If there was one process which they had not the fullest information on, it would be the Haber process, as this gentleman says.

The CHAIRMAN. That was the statement made to the committee by experts from the War Department.

Mr. SCOTT. But they had enough information regarding the cost, I am sure. It was only technical details as to the best catalysts, etc., and the drilling of men to run that particular plant that we are short of information on. It is a dangerous plant to operate because of the very high pressure and the peculiar action of hydrogen in making metal brittle.

The CHAIRMAN. Of course, the testimony of Mr. Washburn—and I hope I am not misquoting him; his representatives are here, and if I am, they will correct me—to the effect of discrediting the arc process not for any particular reason except that it required too much power.

Mr. MOREE. That is correct. If Mr. Scott will read the rest of the sentence he is quoting from.

Mr. SCOTT. Very well, I will. [Reading:]

> In places where very cheap water power can be developed a nitrate fertilizer might be manufactured at a price that might compete with that of Chile nitrate. In other places where high-grade limestone and anthracite or other suitable form of carbon can also be obtained the calcium cyanamide process might prove the best. It may possibly be objected that the Haber process for the synthesis of ammonia, coupled with the ammonia oxidation process, will eventually render all the other fixation processes obsolete, at any rate as far as the production of ammonia, nitric, and nitrate nitrogen are concerned. The committee is satisfied, however, that at a really favorable water-power site nitric and nitrate nitrogen can be produced more cheaply by the arc process than by any other method, and that the calcium cyanamide process at a suitable location can produce a cheaper nitrogenous fertilizer than any other existing fixation process.

That may depend on whether you will accept the cyanamid as a good nitrogenous fertilizer; it is not so, because it is only that depth [indicating] in those tubes.

The CHAIRMAN. Of course, you touched upon that Saturday when you illustrated by the chart showing the savings made in many ways, nitrate of lime can be used more economically as a fertlizer, for the reasons you stated on Saturday?

Mr. SCOTT. It is a nitrate fertilizer; the cyanamid is a cyanamid fertilizer, which, in order to do its work and give up its nitrogen as plant food, has to pass through a urea stage and ammonia stage, and then into a nitrate stage, and from the nitrate stage it goes into the plant. In calcium nitrate and ammonia nitrate you are putting the nitrogen into the ground in the way in which the plant wants it.

Senator MCNARY. Is the cyanamid as soluble in soil and water?

Mr. SCOTT. It is very much less soluble.

Senator MCNARY. But finally, through the chemical and atmospheric action and reaction, it would become soluble plant food?

Mr. SCOTT. Yes.

Senator MCNARY. The process by which it reaches that stage is slow?

Mr. SCOTT. Yes. I have tested fertilizers in my own garden in England, very thoroughly, so far as an amateur can, and at the end of the season I have dug up the cyanamid that I put in at the beginning of the season.

Senator MCNARY. I understand that the two processes are equal in strength but that the assimilative forces are different.

Mr. SCOTT. The nitrogen is the only thing that the plant wants, not the carbon or the calcium, although the calcium acts as a sweetener to the soil. In that respect the cyanamid and the calcium nitrate are about equal, because they both leave calcium in the soil.

Senator McNary. And in value as plant food they have equal worth—the result of the two products is equally valuable as plant food.

Mr. Scott. The nitrogen, when it gets into the food stage has.

Senator McNary. But one requires a slower process of disintegration before it becomes of a character so that the plant can absorb it. What is the difference in time?

Mr. Scott. I could not say. But in addition to that the calcium cyanamid, when mixed with another fertilizer—phosphate—has the tendency to revert that phosphate into the insoluble form, and therefore it can not be added to mixed fertilizers to the same extent that the other nitrogen fertilizers can.

As Canada is the adjoining country and there is certainly going to be something done there, I thought it would be interesting for the committee to have some reference from this book as to what is thought about the Canadian possibilities. In paragraph 604, page 118, it says [reading]:

> It has been clearly shown in the course of evidence given before the committee that Canada possesses exceptional water-power resources accessible to the seaboard and capable of easy development at a cost probably as low as or even lower than that of the cheapest Norwegian powers. There is little doubt that various nitrogen products could be produced more cheaply on the Canadian seaboard than at any other world site. In many other parts of the British Empire where cheap water power is being or could be developed—for example, in New Zealand, Tasmania, Egypt, and India—the manufacture of synthetic nitrogen products could be profitably undertaken.

I think that the particular power which they have in mind there is a very wonderful power on the Saguenay River, which is on tidewater, and it is known to be capable of developing about 1,000,000 horsepower with a very small amount relatively of hydraulic expense, dams, and such like. It is probably next to Niagara from that point of view of developing a very large amount of power with relatively small cost in hydraulic expense.

Senator McNary. And perhaps with a very dependable and average flow?

Mr. Scott. Very—like Niagara River.

Of course, I do not know for certain that that is the particular power they have in mind, but I have heard much about it since I came here, and I know that Mr. Duke had an option on it. It may be that will pass into the hands of a Canadian syndicate. But surely it will be developed some day.

It is interesting from the arc process point of view, in that it is so remote from any place where the power can be used for anything else. None of us who have studied the question can see any use for it except for making nitrates, or some electrochemical product of that nature.

The Chairman. Is there any definite statement as to what process they contemplate using?

Mr. Scott. No. In paragraph 613, page 119, there are these words. [Reading:]

> The risk of sea transit still remains to be considered. In this connection it must be observed that it would have been of enormous advantage to the United Kingdom and the Allies during the present war if nitrogen-fixation installations had been in operation on a substantial scale on the eastern seaboard of Canada. Even assuming a parity in the maritime risks, there is no ques-

tion as to the saving in tonnage and in time that would have resulted from the availability of supplies of nitrogen products and explosives on the Canadian seaboard as compared with reliance on Chile for practically the entire requirements for nitrates.

It may be that when this is developed on the eastern seaboard of Canada they may put in some other process than the arc process. But I can see no reason for it. To take the cyanamid process and put it there you would have to take coal and limestone, and have to put all the other machinery necessary for getting pure nitrogen by the liquid-air process, also it would be necessary to have fuel to raise the steam with which to convert the cyanamid into ammonia. With the arc process there would be no carriage of raw materials.

The CHAIRMAN. In the arc process all you need is power and water.

Mr. SCOTT. And air.

The CHAIRMAN. Of course, we have the air [laughter]. But heat and water are required. Of course, it takes power to make heat. With the other processes, as I understand it and as I understood Mr. Washburn, you must have——

Mr. SCOTT (interposing). Coke, lime, pure nitrogen, and fuel, and then electricity.

Senator MCNARY. Which process is to be employed depends upon the situation that is under consideration—a project might be feasible at one place for one process and not at another. This one you are discussing is purely a question of cheap power. But supposing your power is limited and your coal close at hand and the other ingredients also, the other process would be the more practical, would it not?

Mr. SCOTT. I would hesitate to say "yes" to that, as there are a number of other factors. But on the face of it, it looks as though you were right. I am going to talk about the use of off-peak power from steam-power stations for use in the arc process, and that will throw a little more light on the relative merits of the processes.

The next series of extracts are to deal with the possibilities of improving the arc process. There are possibilities of improving on that, but I just want to make some references to that from this book.

Many scientists and engineers, including the well-known consulting engineer of the General Electric Co., Dr. C. P. Steinmetz, who ranks as one of the most eminent scientific engineers you have in this country and ranks also in that degree with respect to the world, and Mr. C. S. Bradley, who, with Mr. Lovejoy, was the first to make nitric acid from the air at Niagara, believe in the arc process.

Dr. Steinmetz has recently written articles in the Chemical and Metallurgical Engineering Journal giving results of his own investigation and pointing out in what directions further research might usefully be carried on. In the issue of March 3, 1920, and at the end of his third article he says:

It is interesting to note that the rapid expansion by terminating the arc in the throat of an expansion nozzle would give very high concentrations—that is, save most of the NO produced by the arc, without diluting the gases with masses of cold air—and thereby lowering the concentration and thus requiring the enormous absorption plant; a concentration of 4.45 per cent would reduce the size of the absorption plant—which is the largest part of the cost of installation—to about one-quarter of the present size.

Then he follows this with the remark:

> Thus this method requires further experimental investigation regarding its feasibility.

Now, you have very wisely set up a nitrogen research department under Dr. Lamb at the American University. That is one of the things that they might investigate, and I am sure from what I know of Dr. Steinmetz that if he has any further information than what he has placed at the disposal of this paper it is at Dr. Lamb's command at any time he likes to ask for it, because Dr. Steinmetz wants to see the arc process go ahead.

The CHAIRMAN. You are quoting from Dr. Steinmetz?

Mr. SCOTT. Yes.

The CHAIRMAN. Will you state, for the record, who Dr. Steinmetz is?

Mr. SCOTT. Dr. Steinmetz is looked upon as perhaps one of a half dozen most distinguished engineers in the whole world. He is certainly the best you have. He is the head of the research laboratory of the General Electric Co., which is, I believe, the largest research laboratory in the world.

The CHAIRMAN. I have met the gentleman and he also testified before the Committee on Agriculture some years ago, but I wanted your opinion of him.

Mr. SCOTT. I would suggest to you, sir, that you ask Dr. Steinmetz to come and give evidence, and I would like also to interject this remark: These hearings are going to be extremely important. They are going to be of international importance, and if I might suggest it, it would be well to get all of the evidence you possibly can that bears on the subject.

In the same article Dr. Steinmetz says [reading]:

> However, in this case the serious question arises whether an arc at 5 to 10 atmospheres pressure is not materially hotter than one at atmospheric pressure, and as the result thereof the temperature drop during the adiabatic expansion would not be sufficient to carry down to safe temperatures.
>
> An investigation of the temperature of air arcs at various pressures would therefore be of primary importance.

He there suggests another line of research for Dr. Lamb to take up.

The CHAIRMAN. Dr. Steinmetz was appointed by President Wilson a member of the Research Board?

Mr. SCOTT. Yes; and he has put in the articles, the results of some of his work during the war. It is good of the General Electric Co. to let this stuff out, as they could easily have kept it themselves.

To show what the possibilities of the arc process are, on page 47, paragraph 202, of the Nitrogen Products Committee Report, are these words [reading]:

> The arc process is the most direct of all the synthetic methods of manufacturing nitric acid, and any substantial improvement upon its present low degree of efficiency would have a marked effect upon the capital and productive cost. The incentive to improve has not hitherto been pressing, as the process has only been installed where cheap hydroelectric power is available.

A "synthetic" method is that taking nitrogen and oxygen as they exist in the air and blowing them through an arc so that they join them together to form gas to give nitric acid.

The method of taking nitrogen and hydrogen and passing them over a catalyst to form ammonia is synthetic; also it is synthetic to pass ammonia and air over a catalyst to form the same gas we get out of the electric furnace.

The cyanamid process is not synthetic. The sulphate of ammonia process is not synthetic, but the future of the world chemicals industry is with the synthetic processes. Very many products that were previously made in a roundabout chemical way are now made synthetically. All we need to know is what the compounds contain. When we know that,' we bring the elements together, and either by the electric arc or by catalyst we do the thing which nature has been doing. The future of the chemical industries is with the synthetic processes and old-fashioned roundabout methods, of which the cyanamid process is a glaring example, will have to give place to simpler synthetic methods. The comment [reading]:

> The incentive to improve has not hitherto been pressing, as the process has only been installed where cheap hydro-electric energy is available.

Applies to the Norwegians who adopt the attitude that if they do not use that water it will go over the sill anyway. Why bother? And, why bother? They are paying those tremendous dividends; they have made so much money that they wiped out the whose cost of the plant practically, and they are competing, as you see, by the arc process with Chile nitrate and other processes.

I have already read a paragraph showing that as regards the size of the furnace there are reasonable grounds for believing that with modern, large-scale furnaces the yield might be about 10 or 15 per cent higher and the power requirements considerably smaller.

Just to give you an idea of how this business has grown: It started in Christiania University, where Prof. Berkeland had a furnace of about 5 kilowatts; the next step was 50 kilowatts, and the next, I think, was about 300-kilowatt; they then jumped to about 1,000, and now the furnaces are 4,000 kilowatts each. I see no reason why that particular form of furnace and some others should not be made in even larger sizes. It has been stated many times by interested parties that large furnaces do not give better results, but the facts are the other way.

The CHAIRMAN. As the size of the furnace increases the results improve?

Mr. SCOTT. I say so, and some other parties who are interested in discrediting the arc process will persist in saying it is not so.

Senator KENDRICK. Mr. Scott, as it has to do with this present question that we are considering, the plant at Muscle Shoals is equipped with the cyanamide process?

Mr. SCOTT. Yes, sir.

Senator KENDRICK. And your idea is that the other would prove more satisfactory and more efficient and ultimately more economical?

Mr. SCOTT. If you were building Muscle Shoals to-day and you asked my advice, I would say, "Put down the Haber process and the arc process, the one to make ammonia and the other to make nitric acid, and do not bother with the cyanamid." But now it is down. I say "run it, and have the arc process running with it."

Senator KENDRICK. But you would not make that the sole system of manufacture?

Mr. SCOTT. No; certainly not. If anyone came along with an entirely new process I would not put it down there straight away, but I would let Dr. Lamb have an opportunity of investigating it, and if it promised well enough I would have that put in, too. And, as I said on Friday, it is quite possible for some new process to come from a quarter which one does not expect. For example I know that the Japanese are working very hard on this problem, and they are not working on one, but all processes.

Another thing which is very often said against the arc process, and which carries a great deal of weight with nonscientific people, is that it has low heat efficiency. The energy represented by light given by an incandescent lamp is extremely small as compared with the energy that we put into the water-power turbine that drives the dynamo that makes the electricity, or the energy that is potentially in the coal, and which we release when we burn it and raise steam. The low efficiency of the incandescent lamp was one of the arguments that the gas people used to bring up in the old days when we were fighting hard to get electric lighting adopted. They used to say, "Its efficiency is so low, as only about 3 per cent of the energy comes out as light."

Well, you know that the incandescent lamp was controlled by certain patents—in my country the Ediswan Co., which was a combination of the Edison patents and the Swan patents, and in this country almost entirely by the Edison patents—they were doing pretty well, and did not trouble to improve, and we had the incandescent lamp with the carbon filament for many more years than we had business to have it, which always happens when there is a monopoly. But in time the patents began to run out and other people became busy, and the nitrogen lamp with metallic filament came along. The General Electric Co. in this country has probably had more to do with the development of that lamp than any other firm.

When that lamp came on the market, as you will remember, about 1908 or 1909, it immediately raised the efficiency of the electric light from the purely theoretical point of view, to about 9 per cent, or an improvement of about 300 per cent.

When anyone has got a kick against the arc process they bring up that low efficiency of the arc process and they say, "Ah, but you are only getting 3 per cent in the form of these gases made in the arc furnace, as compared with the energy that goes into the boiler as coal or as water power into the turbine."

And it has been very difficult at times to meet that argument. But here are the facts, gentlemen, that with this low efficiency of 3 per cent the arc process can make nitric acid and nitrates and compete with other processes and Chile nitrate.

But do you not see, gentlemen, that the very fact that a process has got a lower efficiency from that point of view is its greatest asset? If you add on to that efficiency 1½ per cent you have improved the all-around efficiency 50 per cent, and if you can compete now with a process that has only got an efficiency of 3 per cent, and you, by improvements—and I have indicated several already, can raise its efficiency to 4½ per cent, you have made it 50 per cent better than it was before.

The CHAIRMAN. You mean by that, Doctor, that there is a possibility of improving it?

Mr. SCOTT. Yes; and the greatest possibilities are in the arc process and not in the Haber, and certainly not in the cyanamid process. Mr. Washburn was here on Saturday and told you—I think he used these words or very nearly so—"We can not improve it; the process will not be any better if you let it lie idle for 10 years and start it up again."

The CHAIRMAN. I think what he stated—the record speaks for itself—was that it won't produce any more in the future or less in the future than it does now; that is, the present facts and the present conditions will be just what they are to-day. Am I right about that?

Mr. MOREE. Yes.

Mr. SCOTT. The chances of improvement are very much less than the chances of improvement in the arc process.

The CHAIRMAN. The committee will now take a recess until 2 o'clock this afternoon, when we will meet in the room of the Committee on Manufactures, in the Capitol Building.

(Thereupon, at 12.03 o'clock p. m., the committee took a recess, to meet at 2 o'clock this afternoon in the room of the Committee on Manufactures, Capitol Building.)

AFTER RECESS.

At 2 o'clock p. m. the committee reassembled pursuant to the taking of recess.

STATEMENT OF PROF. E. KILBURN SCOTT—Resumed.

The CHAIRMAN. Dr. Scott, I think you may proceed.

Mr. SCOTT. When I was quoting Dr. Steinmetz this morning I had already asked the Library of Congress to send over a book in which there were some further statements of his. This book has only now arrived. I would like to put them in now.

The CHAIRMAN. Very well.

Mr. SCOTT. They occur in a discussion of a paper entitled "Electric Power in Nitrate Fixation," which I read before the American Institute of Electrical Engineers on June 27, 1918. In that paper I made a comparison of the cyanamid process and the arc process, and I included in it a table which sets out [indicating] forcibly the complication of the one as against the simplicity of the other.

The CHAIRMAN. Yes, I see.

Mr. SCOTT. You see, I have taken parallel columns, and I show three factories required by the indirect method, employing calcium cyanamid to make ammonia and oxidizing the ammonia to acid by a catalyst, and only one factory the direct method, employing the arc process. Then, the operations; at least 17 separate operations are required for the cyanamid process whereas there are only two operations for the direct arc. In the case of raw materials, eight are required for cyanamid and only three for the direct arc method. Electric energy is used in the case of a cyanamid plant for six separate operations; in the other process it is only used for one or two. Labor in the cyanamid process is required in each of the 17 separate operations, and in the direct arc is only required in two.

In the discussion Dr. Steinmetz said:

> I decidedly agree with Mr. Scott in the conviction that the final solution of the nitrate problem is to be found in the arc flame process or direct process. I have read numerous reports during the last 15 years aiming to prove the contrary, but I have not been convinced, and I have always had the feeling that the chemical engineers who made these reports, while endeavoring to be thoroughly impartial, were so much more familiar with chemical methods and relatively less familiar with electrical phenomena, so that the conclusions derived by them have influenced unintentionally by their familiarity with the one class of work and unfamiliarity with the other class of work.

He then proceeds to debate that point which I raised this morning about the supposedly low heat efficiency of the arc process, and this is partly what he says:

> It is true that the temperature equilibrium at the carbon arc temperature corresponds to 4 per cent of nitric oxide and very much lower percentages at lower temperature. It has been proven, however, that the nitrification in the arc is not a temperature effect, but is an electrical effect, and the proof of that you can find in the transactions of the A. I. E. E.——

Meaning the American Institution of Electrical Engineers—

> In the discussion of a paper by my assistant, Mr. J. L. R. Hayden, who made an extensive investigation some years back on nitrification and has given the results in his discussion. This, however, seems to have been forgotten, since at that time the problem was of lesser importance than now.

The chemists will have it that this is a purely thermal effect, and the chemists are absolutely wrong. It is an electric-furnace problem and it is an electrical effect. Chemical reactions and electrical phenomena go together. I know that many chemists will say there is no electricity performing any function; but it is there. In the same way many electrical effects, which we presume are purely electrical, are partly chemical. Continuing, he says:

> The reason why I have confidence in the arc process is not only due to the absence of the need of any other raw material, but air, which makes it specially suitable for use anywhere where power is available, as pointed out by Mr. Scott at the coke oven, for instance; it is not only the possibility of the use of intermittant power, which holds out the hope of developing a powerful nitrate industry in peace times, but it is also the vast possibility of increasing the efficiency of nitric-acid production by the arc process over that reached in Norwegian plants. Under favorable conditions, I understand, the present efficiency is from 60 to 80 grams per kilowatt hour. The theoretical efficiency of nitric-oxide production is 2,500 grams of NO_3H per kilowatt hour, so that the present best results are an efficiency of 3 per cent.

The Chairman. That corresponds exactly with the statement made this morning?

Mr. Scott. Yes.

The Chairman. You and Dr. Steinmetz agree absolutely?

Mr. Scott. Yes; and I am reviewing the evidence of a well-recognized authority on these matters. Continuing, Dr. Steinmetz says:

> I want to conclude by repeating that my study of the problem—and I have been closely interested in it, not only theoretically, but I have done considerable experimental work during the past 20 years or more—has led me to the conclusion that while the cyanamid process may have immediate use by being the quickest available, that the process which I consider as the most promising, in the final solution of the problem, is the direct or arc process.

I was talking just before lunch time about the sizes to which the direct arc furnaces have been made, and I mentioned that they had grown, in about 12 years, from 50 kilowatts up to 4,000 kilowatts, and apparently they could be made still larger, also that improved results were obtained from the larger furnaces. If that were not so, there would be no progress in the world; everything larger is usually better.

In this connection I want to say this, that in the cyanamid process the nitrifying of carbide of calcium into cyanamid—that is, the addition of the nitrogen to the calcium carbide to form the calcium cyanamid—is carried on, in relatively small electrical retorts. In one factory in Norway, at Odda, there are relatively few electric furnaces for making the carbide—I believe about half a dozen—but there are 196 retorts for combining the nitrogen with the carbide; and the reason is that the nitrogen has to percolate through the carbide. To do it they have to insert in the carbide pieces of papier-mâché, that crinkly paper you wrap up packages in, and it leaves spaces for the nitrogen to percolate through. That is to say, the cyanamid process has to have a very large number of relatively small units of the plant, running into many hundreds at Muscle Shoals. It entails a lot of labor and expense involved, hundreds of electrical connections have to be made and broken every 24 hours.

I have said already that if an arc process plant was put in at Muscle Shoals alongside the cyanamid plant it could make use of the by-product oxygen from the cyanamid. That is one way in which the yield of the arc furnaces can be considerably increased. We do not do it now, because we would have to make the oxygen especially for use; that would mean a large oxygen plant, and probably the increase in the yield might not be such as to justify the extra cost of an oxygen plant. But where you have a process where the oxygen is going to be thrown away, and you are getting it for nothing, the case is different. Oxygen can not be used in the oxidation of ammonia to nitric acid, because it would form an explosive mixture. In the arc process we have no trouble in using by-product oxygen, but in the cyanamid process they can not use their by-product oxygen.

This morning I quoted a statement of Dr. Steinmetz. It was in the Chemical and Metallurgical Engineer, to show that if the concentration of the gas from electric arc furnaces was brought up to 4 per cent it would cut down the absorption plant to one quarter of what it is now. Now, in the arc process a large amount of absorption plant is required to absorb the gases and make them into acid. The gases are passed through large towers, where they meet with water, and the gas is formed with water into nitric acid. Now, those towers are very large and very expensive. If we can bring up the concentration of the gases, as indicated by Dr. Steinmetz, and he suggests that line of research, then we cut down those towers to about one-fourth of what they are now. Absorption towers are expensive, and it may be that they are not going to be required very much longer. There are men working on methods for cutting out the towers, and one of those has been developed by Prof. Guye, a Swiss engineer. On page 241 the nitrogen product report of the British ministry of munitions, referring to Guye's modified system of working, says:

> It has also been shown that the recovery of oxides of nitrogen from the furnace gases can be effected without the employment of absorption towers by cooling the gases to 90° C., nitrogen peroxide separating out in the liquefied form. The product can be stored in steel tanks or cylinders, and marketed for use in different nitrification processes, or can be converted into concen-

> trated nitric acid without the employment of concentrating apparatus by autoclaving with water in the presence of oxygen at a pressure of five atmospheres.

And then it goes on to describe the method in detail, which I need not quote.

That, again, is one of the things which, I take it, the nitrogen research department will investigate. A plant is actually working near Paris quite successfully. So, you see, the greatest expense of the arc process is likely to be very considerably reduced by the introduction of this method of freezing out the gases.

Then, there is further, the use of high pressure. In the electric-arc furnaces everybody works with a pressure of only a fraction of a pound per square inch. We have never bothered to work with high pressure. Now, in the Haber process for the No. 1 plant at Muscle Shoals they have to use pressures of at least 1,500 pounds a square inch to get any result, and they probably would do better to use twice that pressure, and there is a man, a Mr. Claude, advocating now that they use 10 times that pressure. It is a heroic device to get results, and we can also use heroic devices in the arc process; these higher pressures we know will give increased yields?

Now then, as regards labor. I designed a plant for a firm in Birmingham, known as Kynocks (Ltd.). They are, or were, the largest small-arm ammunition manufacturers in the British Commonwealth. They had, at their Birmingham factory, a fulminate of mercury department, and for that they had to have some nitric acid.

I designed a plant for them, and a furnace, to take up to 300 kilowatts. In England we could not get any men; the Government would not release them; and that plant, with its electrical switch gear, transformer for increasing the pressure, the cooling apparatus, the boiler, the absorption plant, the arrangement for getting the product away from the plant, were looked after by two women; one had previously been a governess and the other a maid servant.

Now, as I have just mentioned, in a cyanamid factory hosts of men are required, and skilled men, at that, because all of the operations fit into one another, and if one stops then the whole plant stops. There is nothing like that in the arc process. And if you go into the Birkeland-Eyde plants in Norway to see their arc process working, there are few men to be seen in it; practically the whole is automatic. There is no such thing in the cyanamid process, and the Haber process is still worse, in that it requires very skilled men of the professorial type to run it.

The next point I want to bring up is the use of offpeak power. On page 41 of this report of the Nitrogen Products Committee, paragraph 172, it says:

> Nevertheless, the committee took steps to obtain an estimate of the cost of a unit layout arc furnace installation suitable for the largest blocks of power available, having in mind the fact that the arc process is better adapted for intermittent working than any other of the established fixation processes.

Now, all power plants, all electric power stations, whether hydroelectric or steam have what are known as peaks of load; that is to say, about 4 o'clock in the afternoon, especially in the winter, you get the lighting load and the power load, and the traction load, and the electrochemical and the electrometallurgical load, if there is one, all overlapping. This peak in the load lasts for two or three hours, and you have always to provide generating plant to cover that peak. Therefore, for 18 to 22 hours per day there is a considerable amount of power available, and we call this "offpeak power." All power companies are prepared to sell power at a much lower rate for that period than they are for the peak period. Offpeak is sold at prices comparing very favorably with the Norwegian prices. Now, the arc process is the ideal way of using that offpeak power. Furthermore, it is the only air-nitrate process that can do it. Other processes must run all the time, and it is a lot of trouble to get them started. In the cyanamid process, you could stop down some of the carbide furnaces for a time, but if stopped very long the carbide would freeze, and the nitrification of carbide, which requires a certain number of hours to carry it out, has got to be carried out, irrespective of any peak load. So the arc process is the only one for which you can use offpeak power. Now, there is plenty of offpeak power in this country, as in my country, which could have been obtained during the war for operating the arc process.

Senator KENDRICK. You mean to reduce the number of units in operation during the time of the peak load without upsetting the efficiency of the other part?

Mr. SCOTT. Yes; it is like switching large arc lamps, for really, as a matter of fact, these furnaces are like big arc lamps of 1,000 horse power. You could not possibly do that with a carbide furnace; you would have to have some skilled people around; but anyone can switch an arc furnace on and off.

Senator KENDRICK. How long has this arc process, as you call it, been in actual use?

Mr. SCOTT. In Norway 15 years. Of course, it has grown from very small beginnings. Two big plants in Norway have been running since 1908, and another, of 140,000 horsepower, was started up about three years ago.

Senator KENDRICK. And from what you have told us, they are also using to a larger extent, the cyanamid and other processes in Norway?

Mr. SCOTT. The cyanamid plant is working in Norway, but to my knowledge it has not been increased for some years.

Senator KENDRICK. Is the proportionate growth or percentage of use in favor of the arc?

Mr. SCOTT. Yes. The arc has grown enormously in Norway, and the cyanamid very little.

Senator MCNARY. Are you familiar with conditions in Germany?

Mr. SCOTT. No; no more than what I have read.

Senator MCNARY. What is the popular process there?

Mr. SCOTT. I believe it is stated that more nitrogen is fixed by the cyanamid process in Germany.

Senator MCNARY. The Haber is second?

Mr. SCOTT. I have heard it is second; on the other hand, I have heard the other way—that Haber is in the lead.

Senator MCNARY. What process does England employ?

Mr. SCOTT. They have not got plants running yet, unless it is the small one at Dagenham Dock, which is cyanamid.

Senator MCNARY. Which is the oldest of the three processes?

Mr. **Scott**. The arc process.

Senator **McNary**. You are advocating the translation of the Muscle Shoals plant into an arc-process plant?

Mr. **Scott**. No; I am trying to explain in what way the Muscle Shoals plant is handicapped as at present built. Now it is there, I say run it, but put alongside it an arc process plant.

Senator **McNary**. Is the plant convertible from the present process to an arc process?

Mr. **Scott**. You mean the cyanamid plant?

Senator **McNary**. Yes.

Mr. **Scott**. No. There are parts of the cyanamid plant, such as the towers, which could be used.

Senator **McNary**. You are not advocating an abandonment of the Muscle Shoals plant?

Mr. **Scott**. No; rather the other way.

Senator **McNary**. I was asking that question because I did not attend the meeting Saturday.

Senator **Kendrick**. Is it your opinion, Mr. Scott, that with two plants one would be helpful to the other?

Mr. **Scott**. Yes. And the men would be skilled in working all three of the plants, because the Haber plant down there could be made to work. Why not? It is working well in Germany. Why, if necessary, you could get Germans over to show how to do it. Now the war is over, I presume skilled Germans would be ready to come over here. There is no reason at all why that No. 1 plant at Muscle Shoals should not be made to work.

The **Chairman**. The cyanamid process is a foreign patent. It has been understood, I think, that it is an American patent, which it is not. You people, as I understand it, simply have a contract with them for this country, just the same as England has a contract for England. It was invented by an Italian, was it not?

Mr. **Scott**. It was invented by Drs. Frank and Carso, two German chemists.

The **Chairman**. You heard Mr. Washburn's statement as to the supply and what influence it might have on the price of steel and iron. You heard his statement about that, did you not?

Mr. **Scott**. Why, yes. He was talking about sulphate of ammonia, and I must say right now that I do not see the use of making that. That means making sulphuric acid down there, or purchasing it to join up with ammonia; and he was quite right in stating that the price of sulphate of ammonia would be always governed by the coke-oven business. It is a by-product of that business, and one can set any price on a by-product.

The **Chairman**. And he also stated that the supply was all that could be used in normal times—that is, from the coke ovens.

Mr. **Scott**. That I do not agree with.

Senator **Kendrick**. He made this point, Mr. Chairman: He stated definitely that any lowering of price of the sulphate produced by the coke ovens would increase the price of steel products to everybody who bought those products; that the loss sustained on the by-products would have to be added as an increase to the cost of the principal product.

The **Chairman**. Yes.

Mr. Scott. Yes; it was a statement, and it is very involved. I think any reduction would have very little effect on steel. It is a very involved process of reasoning.

The Chairman. I asked the question for this reason: That I wanted to have your own judgment as to whether it would be possible or feasible to stimulate the use of it. Of course, we know the large portion of the United States has no use for it for agricultural purposes. These compounds are not being used very much west of the Mississippi River, unless it is for orchards, for gardening, or something of that sort. It is not used as a fertilizer in producing cereals or vegetables. Now, that brings up this question in my mind: Let us suppose that we could do what you have suggested, Dr. Scott, and increase very much the supply; and, of course, as a logical conclusion, we would reduce the price; that would probably follow. But would not the result be this: That it would make it possible for a larger portion of the farmers generally to use it, and so to stimulate production?

Mr. Scott. Yes.

The Chairman. Now, I think that is a very great question. Of course, I do not know that we ought to go into it here; still it bears upon agriculture as well as it does on the supply of munitions in times of war for national defense, and it is possible that Mr. Washburn has overlooked that phase of the question.

Mr. Scott. As I take it, if you ran Muscle Shoals you would make fertilizer which you would supply in parcels to all the agricultural colleges in the country and they would make the same kind of experiments that have been made in England and Germany and France and Norway and Italy, etc. They would test these various fertilizers on various crops with various soils. The result of these experiments would be published, and there would be propaganda work done among the farmers. I presume lecturers would go out and advocate the use of these fertilizers——

Senator McNary (interposing). What is the practical value of using a little homemade fertilizer on a few bushes around agricultural colleges to the farmers of the country and the fruit growers and the vegetable gardeners? If this is going to be successful it has to compete with the Chilean nitrate and with green manures and barnyard manure. Now, can it compete with any of these well known fertilizers that are used in vast quantities all over the country and which must be used in increasing quantities in the future?

Mr. Scott. Well; yes.

Senator McNary. Well, how cheaply can you produce it, taking into consideration cost of production and of transportation from those places far inland?

Mr. Scott. Now, take the first part of your question, about the small plots of ground. Experimental farms where these experiments are carried on are not small. Those connected with agricultural colleges and universities in England are large farms.

Senator McNary (interposing). I am not speaking of England. I am speaking of this country. I may say that I have some knowledge of that.

Mr. Scott. I would not call the one down at Knoxville small; it is big, and they are equipped for testing out these fertilizers quite well.

Senator McNARY. Well, Doctor, you do not understand me. You can test it out and it is the proper way to do; but when you have demonstrated that certain chemicals, certain combinations of chemicals, are right for the West, and others for the South, and know what are the various ingredients that go to make the well-balanced fertilizer suited to the different localities—supposing you have demonstrated it out in Oregon, where I live, a certain combination that makes a perfect fertilizer for that country—can you produce that fertilizer at Muscle Shoals and compete with the fertilizers I have mentioned?

Mr. SCOTT. Well, there is a plant going up now in British Columbia, an arc process, which might supply that part of the country, and you would not need to bring it all the way from Muscle Shoals.

Senator McNARY. But can you compete in Kansas or in a radius of a thousand miles, or a hundred miles, or right next to the plant? Can it compete with these fertilizers I have named?

Mr. SCOTT. Yes, sir; I think in the South; you could get rid of all the fertilizer made at Muscle Shoals; you would not need to take it across the country to Oregon.

Senator McNARY. Well, what would it cost? Supposing I am a cotton grower, living within 50 miles of this plant, and use my own trucks. What could that be sold for f. o. b. the trucks at Muscle Shoals?

Mr. SCOTT. I confess I could not tell you.

Senator McNARY. That is what I wanted to know. Where do you get that data from; can you tell me? Where do you get the data showing that it will compete with barnyard manure?

Mr. SCOTT. Barnyard manure is going down in quantity every year. With the increasing use of automobiles the supply of barnyard manure is, of course, decreasing.

Senator McNARY. Notwithstanding the automobiles, there are more horses in the country to-day than ever before; and more cattle and sheep and hogs. That may sound startling, but we have got statistics for it. But aside from that, you say you can sell it successfully, yet you do not give any figures or estimate as to how much it is going to cost a farmer for enough to fertilize an acre of cotton, or for a ton, or for a pound.

Mr. SCOTT. In evidence which you have not heard I have shown that nitrates made from air are competing successfully with Chile nitrate, barnyard manure, etc., in other parts of the world; so why not here?

Senator KENDRICK. I was just going to say that I believed that the question would be answered according to local conditions, Senator. Take as an illustration, they will undoubtedly have to use this fertilizer, whether they like or not, in the Southern and Southeastern States, because the soil is so badly leached out that they can scarcely raise crops without it; and they raise a high-classed crop under present conditions. Now, I take it, in our western country it is a good deal there as if they had attempted a plan to use fertilizer in this country 140 years ago. They get along without it because the soil is full of rich fertilizer; and besides, we are farther away from the market, and we have to pay more to get the fertilizer shipped in, and have to pay more, of course, to ship out our product. But as I have listened to the discussion about the use of it, I am impressed with the statement Senator Gronna made a minute ago. If we could produce these nitrates, as I understand it, we can draw upon our local products for all of the potash and all of the phosphate we want to go with them. It is one of the astounding developments of the war, the natural supply of those different kinds of material. In my case, out in the neighborhood of Green River, Wyo., it was estimated there is enough phosphate rock to do this country, I think it was estimated, 180 years, if they did not depend upon any other place for it; and the mountains of the West have enormous beds of phosphate rock that they have never touched. My impression is, without knowing much about it—not as much as I ought to—that these materials ought to be mixed with nitrate. If we could produce this, it would take the place of the one thing that we have not otherwise in the country in the way of fertilizing material. It might have the effect of increasing, as Senator Gronna says, the use of this kind of material all over the country.

Senator McNary. That is true, if it can compete with other fertilizers containing the same ingredients and elements. Of course, we all know that the land power of the country is becoming exhausted from continuous use. That is true, and we require some of these elements to be placed back before you can get this soil at its virgin force. But this does not mean that you can place this on a trial—and you would not do it unless it could compete with other fertilizers. The packers put out an excellent fertilizer, containing about 18 per cent of nitrogen, mixed with other elements that make a well-balanced fertilizer. Then you have your Chilean nitrate; it comes in competition with those, and your barnyard manure, and there is a great possibility for a man who really understands farming to fertilize with the use of green manure. I confess it is not generally practiced in the South, but it is in the West. You can only handle this fertilizer, and it will only be used on the soil, unless it is as cheap as the other. You have got to look at it from that end. Because you are making it down there, and because the man needs this fertilizer, it will never go to the ground unless it is able to compete in the market with the other fertilizers. Now, I would like some practical testimony that it will do that.

Col. Burns. On page 92 of the hearings, Senator McNary, that were held by Senator Gronna with the representatives of the War Department, we outlined what the cost of the various nitrogen products would be at Muscle Shoals and the expected selling price, and we showed that we could compete with the ordinary forms of nitrogenous fertilizers and at the same time make money.

Senator McNary. You have not demonstrated it; those are your figures.

Col. Burns. Of course we have not demonstrated it, because we have not operated the plant.

Senator McNary. About when was the estimate made, and by whom?

Col. Burns. Last summer, by various representatives of the Government.

Senator McNary. The Bureau of Crop Estimates?

Col. Burns. No, sir; by representatives of the Ordnance Bureau of the War Department.

Mr. SCOTT. The farmers in Norway, Sweden, and Denmark were receiving their fertilizers from the arc process in Norway. I have come across this excerpt from Handelsberichten, of June 13, 1918:

> The home consumption of nitrogenous fertilizers in Norway increased from a prewar figure of 6,000 to 7,000 tons to 20,000 tons in 1917 and to 55,000 to 60,000 tons in 1918.

Then, underneath that are given the figures of exports of fertilizers from Norway; they are given as ammonium nitrate, nitrate of lime, and cyanamid. Ammonium nitrate could be used and was used for explosive purposes. Nitrate of lime could be used only for fertilizer. The export from Norway in 1913 was 70,900 of nitrate of lime. In 1914 it was 75,176 tons, and in 1915 it dropped to 38,609 tons, because of the war. In 1916 the export was 46,000 tons and in 1917 35,920 tons. Now, that was all used for fertilizer. It was all made by the arc process from air, and a good deal came to England. Some of it went as far west as California before the war, and it is going there again now, because they prefer it to Chile nitrate. It even goes as far as Honolulu.

Senator KENDRICK. I was going to ask Col. Burns if he happens to know, and happened to recall the figures offhand of this product that was employed in this country in the way of fertilizer before the war, and as to whether or not that amount was increasing or decreasing?

Col. BURNS. Senator, the employment of these various nitrogen compounds for fertilizer is constantly increasing.

Senator KENDRICK. And do you know about what is the ratio of increase?

Col. BURNS. The best estimates we can make are to the effect that the use of inorganic nitrogen, which is what we are discussing, doubles about every 10 years, not only in the United States, but throughout the world. The organic nitrogen fertilizer that has been generally used for many years is constantly being replaced by the inorganic, because the organic material, such as cottonseed meal and dried blood, etc., is being used as a foodstuff now. It is too expensive to put back into the ground to raise the feed the second time.

Senator KENDRICK. I know we paid $84 a ton for it last winter, not the cottonseed cakes, but the hulls of the cotton seed.

Col. BURNS. Yes, sir; I believe that cotton seed to-day is more expensive than corn, and, of course, no one here would think of putting corn back into the ground as fertilizer.

Senator KENDRICK. Yes; it is very much more expensive. You can buy chopped corn in our country for 3 cents a pound. Cottonseed cake, as they call it—it is largely hulls—I think that cotton seed costs us something more than 4 cents; about $82 to $84 a ton.

Mr. SCOTT. Mr. Washburn showed some curves when you were not here, Senator; and he drew a line up to the beginning of the war, and another line [indicating] showing the increase of nitrates during the war for explosives.

There is a 10 per cent increase every year; and the very fact that vast amounts of nitrogen has been thrown away during the war, and the whole world is dying for nitrogen, means that we are going to have to supply relatively much more nitrogen.

Senator McNary. Is it true that where the nitrates are used on the land and no crops produced from them that it leaches out and is almost without benefit?

Mr. Scott. Yes; nitrogen has that effect, that you are liable to lose it; and that is partly why they are using it as a top dressing.

Senator McNary. Does that leaching occur when it is left on the surface, or after the soil is placed over it?

Mr. Scott. In both cases.

Senator McNary. But very much more, evidently, when it is not covered. The same applies to horse manure or Chile nitrate. They leach if not covered and lose a great portion if not properly covered.

Mr. Scott. I am a little astonished to find that it should be necessary to emphasize the use of these artificial manures in this country. It is because of your virgin soil out West, of course; but in Europe we can not grow anything at all, in any part at all, without putting plant foods into the soil. Belgium and Germany are the two countries where they produce the greatest crops per acre and where most artificial fertilizers are used per acre.

Senator McNary. Well, that is intensive farming. You take a fair-sized western farm and rotate the crop—for instance, you take clover, and you perform the same thing that your plant food does. You turn that under and plant two crops, or one crop of corn and a crop of wheat, and sow your vetch in the soil and turn it under in the spring; you keep up indefinitely the fertility of your soil without using any of these artificial fertilizers.

Col. Burns. Senator, with reference to this consumption of organic and inorganic fertilizer, if you will turn to page 74 of the hearings you will see our best effort in putting down in figures the rate at which inorganic fertilizer has increased in the United States, and the rate at which organic nitrogen has decreased in the United States. It shows that there is a very pronounced reduction in the amount of organic fertilizer being used each year, and on the other hand a very great increase in the amount of inorganic fertilizer, and pretty nearly everybody knows that in a few years practically all organic nitrogen, the green goods, will have disappeared.

Senator McNary. Legumes?

Col. Burns. Yes, sir; we have not included those in our tables, because no one knows the amount used, and they will continue, undoubtedly, to be used as time goes on.

Mr. Scott. Regarding the rotation of crops, it is stated by Mr. Mann, on page 3350 of the Congressional Record:

> In the South, however, with the high average temperature and rainfall, it is doubtful if it would be possible to maintain enough legume nitrogen in a soil to secure a high production of food product, because of the great destruction of the organic matter in which such nitrogen must be held from the bacterial action and leaching when crops are not taking food from the soil.

Senator McNary. I have seen in the West, in the prune orchards, and apple and pear orchards, trees after 25 to 40 years bearing as well now as they ever did; they simply plow under annually these legumes, without using any fertilizer whatever. Perhaps that would not apply to the South, and while that has not anything to do with your plants, I thought it might be considered in connection with the cost and the practical use of this product.

Mr. SCOTT. Yes. Of course, one line that I have been taking all along is that you have got to have that Muscle Shoals plant for national defense; you have got to have a factory for making nitrogen from air so that in the next war, if it comes, you will not have to depend upon Chile nitrate. The entire supplies in Germany from 1915 were obtained from the air, of course, and now they are in a position to supply Europe with fertilizers made from air at a much lower price than the Chile nitrate can be supplied from Chile. Not only that, if you are going to build up a dyeing industry here you want some of these products that we are talking about. You want sodium nitrite, most decidedly, and it is a by-product of one of these processes—the arc process. It is coming into this country now from Norway at the rate of at least 5,000 tons a year.

The CHAIRMAN. There is a great deal of force in the argument of Senator McNary, that unless you can compete from a commercial standpoint, the question is whether it would be practical to use it at all. Now, you take it in the Middle West, the way we farm on a large scale, it would be impossible for us to get enough barnyard manure, so we simply employ what we call summer fallow. We skip one year and do not crop, do not take the crop off at all, we simply let the weeds and everything grow until it gets to a certain stage, then we plow it under——

Mr. SCOTT (interposing). Those are legumes.

The CHAIRMAN. Yes; and we plow that under and then we keep on constantly cultivating it, especially after every rain, or especially after every heavy dew. We keep on dragging it and cultivating it, and in that way we conserve the moisture and help to deposit some of the nitrogen. That is a very slow process. And, again, we grow clover and alfalfa—alfalfa is a species of clover, of course—and you can almost bring land back to the original stage by the proper use of clover. Of course, clover will only be good, without reseeding, for two or three years; but if you take off the first crop—there is no seed in the first crop, as you know, in clovers—and then let the second crop stand; of course it will reseed itself, and in the course of four years you would have perfectly new land. But that is very expensive—tremendously expensive—even for one year; and when you figure your work which is going on and the interest on your investment which is going on, and you get no returns. Now, the question is, Would it not be more profitable to have an expenditure of, say, $2 or $3 an acre and then take a crop off every year? There is no question in my mind, from what little study I have made of this question, but what it would greatly increase the production of our crop; that we could increase the yield. Of course, Germany has been, I think, the most successful of any nation in the world in intensifying and raising large crops. Where we, on an average, raise 12 bushels of wheat to the acre, Germany often raises 30——

Mr. SCOTT (interposing). And Belgium still more.

The CHAIRMAN. Belgium, of course, is a smaller country. Now, that becomes a very important question. If we can manufacture these nitrates at a price so as to make it possible to use them as a mixture with other ingredients which necessarily go into fertilizer and put them on the land every year and produce crops every year, we would be assured that we would have no real failure—that is, throughout the entire country. We would have failures anyway in some localities because the elements are such that you can not always get a crop; you may start it and all that, but there are so many other things to encounter. But that does not happen throughout the entire country in a country as large as the United States. We may have hailstorms; we may have blights, rust, drought, and such things as that; but that will be only local. It seems to me that we could be absolutely sure that with the large area which we have—over 3,000,000 square miles—that we could be sure of producing an abundance of everything we need almost any year; and, of course, that is a question which I think we are going to think more about in a year or two than we do now.

Mr. BOWER. With reference to your statement about legumes and their cost, that cost has increased tremendously by the increase in the value of your lands out there, and as the price of land goes up it continually increases the cost of legumes; it could not help it; take your interest on the money in your land, the $400 Iowa land, an acre of legumes now is very expensive.

The CHAIRMAN. And labor, and——

Mr. BOWER (interposing). Yes; and all of those things.

The CHAIRMAN. And labor and the cost of machinery.

Mr. SCOTT. You said something about the relative cost of these electrical methods as compared with Chile nitrate. Before the war we were receiving from Norway considerable quantities of sodium nitrate, the same as Chile nitrate, made from air. It was selling under the Chile nitrate price in England, and it was purchased by the people who make it into explosives and into fine chemicals, because it was absolutely pure; the Chile nitrate never is pure; it has other things in it.

Another point about ammonium nitrate: The Muscle Shoals plant was built to make ammonium nitrate for the bursting of the charges of shells and for mines and torpedoes, etc. Now, ammonium nitrate, as I explained the day you were not here, Senator, has got ammonia and nitric acid. It has 35 per cent of nitrogen in it, therefore a higher percentage than in any form of fertilizer; and the nitrogen is in two forms, ammonia nitrogen and nitrate nitrogen, and some plants thrive better on one, and some better on the other. Now, it is a very excellent fertilizer.

The CHAIRMAN. Doctor, do you care to touch upon the question discussed by Mr. Washburn with reference to the quality of the chemicals produced at Muscle Shoals, that they were not propelling explosives, they were simply bursting explosives used in shells?

Mr. SCOTT. The most successful burster charge of the war was amatol. It is a mixture of ammonium nitrate and T. N. T. A propellant explosive does not require any ammonia; it only requires nitric acid. Inasmuch as you require nitric acid to nitrate the toluol to make T. N. T. or trinitrotoluol and in addition nitric acid to make the propellant, you require more nitric acid in war times than you do ammonia. Now, the arc process is the ideal way of making nitric acid. It is the substance which the arc process produces, whereas the cyanamid and the Haber processes, which are established at Muscle Shoals, make ammonia; so in case of war you either must put down again a very large plant to treat Chile nitrate and depend on Chile nitrate to make your propellent explosives and the T. N. T. to go in with the ammonia, or you must make nitric acid from the air.

The CHAIRMAN. I think that is a very important matter, because you must have something to mix with this compound before you can make a propellent explosive. Now, from the arc process you make——

Mr. SCOTT (interposing). Nitric acid.

The CHAIRMAN. Nitric acid. There is not anything required to be mixed with it?

Col. BURNS. Pardon me for interrupting, Mr. Chairman, but the statement has been made that the nitrogen that you get at No. 2 plant at Muscle Shoals can not be used in the manufacture of propellent explosives; such is not the case. You can convert that nitrogen into such a form as will allow it to be used in the manufacture of powder for propellant explosives. It is true it has to be turned into nitric acid and distributed to the various ammunition plants throughout the country; but it can be done; we did do it. I wanted to get the idea out of the committee's mind that that nitrogen down here would not be valuable for military purposes, because it can be made available.

Mr. SCOTT. Yes; we do not disagree, Senator, but I said that the nitrogen plants at Muscle Shoals were primarily built for the manufacture of ammonia nitrate.

Col. BURNS. Yes, sir; that is correct.

Mr. SCOTT. But they can be used to make nitric acid by changing the ammonia into nitric acid; but the arc process makes nitric acid direct from the air in one process.

The CHAIRMAN. The question would be whether that was the most practical way to do it; whether it is the most expensive or the most inexpensive way. I suppose that you could make it out of almost any substance if you had enough of it. You could make this particular compound out of wheat, if you had enough of it, but that is too expensive.

Col. BURNS. That was for war time I was speaking of, Senator; I was arguing about the military value of the plants.

The CHAIRMAN. Yes.

Col. BURNS. In time of peace we would only make the compounds that were the best sellers.

The CHAIRMAN. The other would not be practicable in peace times?

Col. BURNS. Well, I do not know; it would be the economical thing to do in peace times to distribute the nitrogen to the various powder manufacturers from No. 2 plant.

Senator KENDRICK. As I understand it, you have two plants, No. 1 and No. 2?

Col. BURNS. Yes, sir; the No. 1 is the Haber type. It is experimental in nature and not sufficiently developed to——

Senator KENDRICK (interposing). And how far apart are those?

Col. BURNS. About 5 miles.

Senator KENDRICK. And how far are they away from this site of your power plant at Muscle Shoals?

Col. BURNS. The No. 2 plant, the cyanamid plant, which was constructed by the American Cyanamid Co., is practically abreast of the dam in the Tennessee River that is being erected. The No. 1 plant is about 5 miles down the river from the power plant.

Senator KENDRICK. You would expect to transmit the power from the falls to that No. 1 plant?

Col. BURNS. Yes, sir; the transmission line is in process of construction now.

Senator McNARY. Who owns the power site?

Col. BURNS. I believe the Government owns it completely. That power, Senator, is being handled by the Corps of Engineers of the Army; it is not being handled by the Ordnance Department, of which I am a member; but I feel pretty certain that the entire site has been purchased by the Government. The dam is now in process of construction and several million dollars have already been expended; that amount of money has been spent in development.

Senator KENDRICK. What is the developed horsepower?

Col. BURNS. The reports of the engineers are to the effect that it will have a continuous horsepower of approximately 100,000. There will be a secondary power available for some eight months in the year that will be two hundred and fifty or three hundred thousand—they do not give you very definite figures on that—so that the total power available eight months in the year will be some 350,000 horsepower, and for the entire year it will be 100,000 horsepower.

Senator KENDRICK. Well, I asked that question at the first hearing we had, when the Secretary of War was there, and the Secretary of War——

Col. BURNS (interposing). No; it was Mr. Roberts.

Senator KENDRICK. It was an officer that was on the stand at the time; or, at least, he answered the question. He said that the Government had practical control of all the territories included within the power site; they had control of nearly all of it; that is, absolute control; and had, I think, plans for obtaining complete control of it all; that was my understanding.

Col. BURNS. I think that is substantially correct.

Senator KENDRICK. But there was still some land they expected to get.

Mr. BOWERS. As I remember, the Secretary's statement was that there were one or two small pieces of land down there that they were having trouble about; and they were preparing condemnation proceedings to get it.

Mr. Chairman, there has been so much discussion of this power, and it is so vital with reference to this proposition, that I have taken the liberty to suggest to the Engineer Department, and I had intended to speak to you about it, to see if we could not get a member of the Corps of Engineers to go into this power feature of it before the committee. I think it would be very advisable, because I am not an engineer. I have studied the Muscle Shoals power for a good many years in connection with this proposition—since Congress first took interest in it—and it was my understanding that there was at Muscle Shoals from two—over 200,000 what is called primary power—that is, power that is commercially available the entire year around; and that, in addition to that, there is a secondary power, such as Dr. Scott might use in an arc process; cheap secondary power that is available six to eight months a year, amounting to over 200,000 horsepower; and I think it would be very expedient for the committee to have the Corps of Engineers explain that power-development proposition there, because, I think, it is vital to this whole proposition.

The CHAIRMAN. Yes. Mr. Scott, have you anything further that you wish to offer?

Mr. SCOTT. In addition to the off-peak power of every 24 hours, you get "out-of-season power," or, as it is called, secondary power. An ideal way for using that is by the arc process.

Mr. Washburn spoke very strongly against nationalization. I have lived in Australia, where all the railways are nationalized, and they run perfectly; and I have visited in New Zealand, where the railways are nationalized, and where some coal mines are nationalized, and they work all right. The question arose, when they wanted to make explosives in Australia, as to the means to do it, and the Federal Government simply said, "We will do it." They secured land, up in the mountains, away from the seaboard, and put down a national factory. Wars would be very largely stopped if explosives were controlled by the governments—if these productions were controlled by the governments instead of as they are now, by the armament makers. The Boer War was precipitated by the quarrel with President Kruger about that very matter of explosives supply. He wanted the dynamite for the Rand mines to be supplied by the Transvaal Government, and he was thus going to control the gold-mining industry in the Rand. It was the international capitalists in there who objected to that national control of the explosives, and that is why I say it was the explosive manufacturers who helped to bring on that war.

The CHAIRMAN. The Boer War?

Mr. SCOTT. Yes. It was the armament manufacturers who joined with the junkers and the Hohenzollerns and brought about the late war.

The CHAIRMAN. You were speaking of the Boer War?

Mr. SCOTT. Yes, sir; and there were numbers of people in England who objected to the Boer War. I believe if the nations of the world would get their heads together and control the manufacture of explosives from now on that would do more to stop wars than all the talk. Explosives are the very essence of war, more vital than the men.

Senator KENDRICK. That could be done through the agency of the League of Nations, could it not?

Mr. SCOTT. It might be; I do not know; but I say it would be better for your explosive factories to be controlled by the Government than by private enterprise.

Senator KENDRICK. I thought maybe it might be a good plan to ask Mr. Scott as to what his ideas were as to the further development of the plants that we have under construction here, if he has given it any thought as an engineer, as to whether or not it is advisable to build a new plant for this arc process, or whether to supplement some of the processes we now have in it and carry on others.

Mr. SCOTT. I would carry on that No. 1 plant with all the skill and all the men, and if necessary, get Germans over and get that

No. 1 plant, the Haber process, running. The process runs well in Germany. As to No. 2 plant, I would run only a portion of the cyanamid plant. Then I would suggest that you do not build any sulphate of ammonia plant but spend the money on an arc process. Why spend $900,000 for making sulphate of ammonia, the price of which will be controlled by the coke-oven plants anyway? Install an arc process and make ammonium nitrate and calcium nitrate fertilizer.

Senator McNary. Such an arc process plant as you have in mind, what would be its probable cost?

Mr. Scott. Well, I have not gone into that; but in Mr. Arthur Glasgow's estimate of October 22, 1919, in the hearings of this committee, $900,000 is allowed for a sulphate of ammonia plant and $300,000 for acid storage plant. You may use that.

Senator McNary. Have you not some notion of the water power capacity there? What would such a plant as you would build cost?

Mr. Scott. It would be an enormous expenditure to use up 100,000 horsepower. I was speaking of only a nucleus plant.

Senator McNary. Now, I appreciate that. You have, then, a mental picture of such a plant as you would build, such an arc process plant as you would build down there. How much money would you invest in such a plant?

Mr. Scott. For 5,000 to 10,000 kilowatts, approximately.

Senator McNary. Estimate its cost in round numbers.

Mr. Scott. About $150 a kilowatt.

Senator McNary. I thought perhaps you might estimate it in round numbers.

Mr. Scott. A 5,000-kilowatt plant would be sufficient to make a unit. I would not put a large plant in at first.

Senator McNary. What do you estimate it, Col. Burns?

Col. Burns. Well, he said $150 a kilowatt, and 10,000 kilowatts, that would be $1,500,000. Five thousand would be $750,000.

Senator McNary (interposing). Col. Burns, what headway had you made toward the making of explosives at the close of the war—at the signing of the armistice—at Muscle Shoals?

Col. Burns. I think the plant was just about getting into operation. It was practically complete, and in order to prove out the plant there was a two-weeks' test run made in the early part of January, 1919, in order to find out whether or not the plant could produce in proper quantity and proper quality and at reasonable cost. And, as Mr. Washburn said—I think we are in entire agreement on that—the plant proved out to be excellent in every respect. It is thoroughly capable of producing its allotted quantity of ammonium nitrate, and this is of excellent quality. There is no question of the ability of that plant to produce.

Senator Kendrick. It did not produce anything in time of war?

Col. Burns. Of course, it was not started in time——

Senator Kendrick (interposing). I do not care for explanations, but that is the fact, is it not, that it did not get into the war at all?

Col. Burns. No, no.

(Subsequent to the close of the hearing a letter was received from Mr. Scott, which, by order of the chairman, is here printed in full. as follows:)

NEW YORK, *May 3, 1920.*

Senator GRONNA,
Room 326, Senate Office Building, Washington, D. C.

DEAR SENATOR GRONNA: With further reference to my statement given at the hearings, that some of the operations in the cyanamid plant are dangerous, I would like to say that this is well known among electrochemists and it has been referred to by Mr. Landis in papers read before the American Electro-Chemical Society. It was also stated publicly in the British House of Commons about three years ago.

The men who work amongst cyanamid have to be swathed with bandages around the legs, arms, and chest, so as to reduce as much as possible contact of the powder with the skin. This can not be prevented altogether and the effect of the cyanamid is to produce a rash not unlike that of scarlet fever. When it reaches a certain stage the limbs swell and there is danger of blood poisoning.

In addition to the above it is a well-known fact that cyanamid dust, taken into the lungs, has a serious effect upon the heart's action. The effect of drinking alcohol among men whose lungs are impregnated with cyanamid is to produce what is commonly referred to as the "cyanamid flush." Most of the men who work in the grinding department of the cyanamid factory at Niagara Falls are ignorant Chinamen, and the turnover is very large because they leave when they find out the unpleasant symptoms attendant upon their occupation. I understand that Negroes and Texans were employed at the cyanamid plant at Muscle Shoals.

I should have stated that Chinamen were employed at the Niagara plant, and not Negroes. Otherwise my statement was absolutely correct as to the danger.

Yours, sincerely,

E. KILBURN SCOTT.

The CHAIRMAN. Now, Dr. Landis, do you want to ask Dr. Scott some questions?

Dr. LANDIS. I have some questions to ask, but I would rather present them in the form of testimony.

The CHAIRMAN. Very well; you may proceed.

STATEMENT OF MR. WALTER S. LANDIS, 511 FIFTH AVENUE, NEW YORK, N. Y.

Senator MCNARY. What is your occupation? What experience have you had in this matter?

Dr. LANDIS. Mr. Chairman, I am connected with the American Cyanamid Co. I am in their technical Department, and have been connected with them for just about 10 years. Prior to that time I was a professor in a very prominent technical school in this country in electrochemistry and electrometallurgy, and——

Senator MCNARY (interposing). What was the school?

Dr. LANDIS. Lehigh University. I left the university as an associate professor. My education was not entirely gained in this country, as I attended really four, but I hardly count two, foreign schools, because I only spent time enough to amount to anything at two of the four schools where I registered.

The CHAIRMAN. Where were those schools located?

Dr. LANDIS. They are in Germany; Heidelberg and the high school at Aix la Chapelle. I wish, however, Mr. Chairman, that you could divorce me from the American Cyanamid Co. in this matter, and take the knowledge which I desire to offer to you here as that coming from an engineer, and backed by the ethics of a very honorable profession. Unfortunately, it seems impossible to dissociate me from my connection.

Senator MCNARY. How long have you been connected with this institution?

Dr. **Landis.** I was consulting engineer for them while still at the university, and have been permanently connected with them for eight years.

Senator **McNary.** And are still in their employ?

Mr. **Landis.** Yes, sir; and I say it is unfortunate, because I should like to present the information that I have as a matter of fact and supported in just the extent of my ability by documents which come entirely independent from the American Cyanamid Co.

Senator **McNary.** I do not think this committee will be misled by any prejudice.

The **Chairman.** I was going to say that from my knowledge of the members of this committee I do not think it will make any difference whatever whether you are connected with the American Cyanamid Co. or whether you are a college professor or whether you come from Norway or are connected with the arc process or whether you have any alignment or association with some association in England, so far as I am concerned, and I am sure that is the way the other members of the committee feel about it.

Senator **McNary.** I think most of the committee will make reasonable discount, Mr. Chairman.

Mr. **Landis.** Mr. Chairman, that suggestion was based upon the main conclusion stated by Mr. Scott, that I believe the information placed before this committee is of international value, and I would like to see it made of that value, not only with respect to the committee as such——

The **Chairman** (interposing). You may proceed to make it along those lines.

Mr. **Landis.** I would like to take up a few points, particularly those called up by Dr. Scott; first, as to a history of the arc process in America. I feel I am competent to give you the history of electrochemical processes. I to-day am president of the national society which fosters that industry. I am not coming here as a representative of that society, but it, at least, will give you the basic information to show that I have been connected with the electrochemical industry for many, many years, holding the highly honorable position of president of the national society.

The arc process, we were led to believe in Mr. Scott's early testimony, reached its first commercial development in England. That is not true. The arc process—the very first commercial attempt at installing and completing a factory for this process on a large scale—was at Niagara Falls, N. Y., by Mr. Bradley and Mr. Lovejoy.

Senator **Kendrick.** Mr Chairman, I may be incorrect, but I have the impression that Mr. Scott said this commercial employment of this process originated in Norway. Let us have Mr. Scott clear up that, so as to be sure.

Mr. **Scott.** I believe the first acid made from air was made by MacDougall and Howles, in Manchester, and just a little before Bradley and Lovejoy got busy over here. The plant in Manchester was fairly large, but not a commercial plant in the sense of that of Bradley-Lovejoy. I think the Norwegians, Birkeland & Eyde deserve most credit for sticking to it and making the arc process the financial success which it now is.

Mr. **Landis.** Bradley and Lovejoy were two Americans. Bradley was essentially an electrochemist. Lovejoy was more particularly on the chemical side, and that plant was built at Niagara Falls, N. Y., and set in operation about 1902, and I had the very good fortune of spending quite some time in the plant. It antedated any other possible consideration of a commercial sized plant, because I have here Dr. Eyde's own references as to the then existing sizes of his own installations. That plant was not a commercial success, and in 1903 the company failed and the process went out of existence, and that process failed at Niagara Falls, N. Y., not because it was an arc process, but because it was not possible to build a large scale apparatus.

Senator McNary. You say the process went out of existence, or the present use of it went out of existence? The process by which it was made was known and kept, of course, and later on employed?

Mr. Landis. Supposing I change that and say that the company went out of existence?

Senator McNary. Yes.

Mr. Landis. I will qualify as to that process itself, it being known as the Bradley and Lovejoy process; it is extinct, and will never be revived again. There are a great many arc furnaces. Mr. Scott has one and there are two or three others that have been tried in this country, so that the arc process is not one process that applies to all, I think, as I will show you later on.

That Bradley and Lovejoy experiment, if you wish to call it that, failed because the peculiar type of apparatus used did not lend itself to being built in large scale units, and to start a nitrogen industry with a large tonnage, as any fixation process must have to exist, it must have large units to exist. The Bradley and Lovejoy process was a failure. As a scientific matter, the yield of nitric acid per horsepower that went into that process was probably equal, if not, and I am quite certain, superior to most of the present day processes that are in existence; but the unit was entirely too small; but they made nitric acid, and marketed it as long as they operated.

The next history of the arc process in this country was in connection with Alabama. In 1906 Mr. Washburn, who is a water-power engineer primarily, located what he considered a very advantageous power development in Alabama. He had to find some utilization for that power, and he made a special trip to Norway in the year 1906 and met Dr. Birkeland and Dr. Eyde, who, by the year 1906—they had started experiments about 1902 or 1903, almost simultaneously with Bradley and Lovejoy—by 1906 had developed a promising process for the fixation of nitrogen. And as a load for this power plant to be built in Alabama, it offered a most promising process, because it uses such enormous quantities of power in comparison with other raw materials for the quantity of the product made. A very thorough investigation of the arc process was made at that time, and a very thorough and comprehensive study of the fertilizer situation in this country was made, and Dr. Eyde and the engineers of the Norwegian company did not recommend that Mr. Washburn attempt to start the arc process in Alabama. There is no criticism, and I do not want it understood as a criticism of the arc process. I am just as firm a believer in the arc process as Mr. Scott is, in his place and with its proper settings. But Alabama did not happen to be the proper place and proper setting for that process, and the Norwegian engineers understood it just as well as we did.

The CHAIRMAN. When you say Alabama, you mean Muscle Shoals?

Mr. LANDIS. At that time it was not Muscle Shoals, because there were no schemes for developing that power which did not involve more money than the ordinary individual could have gotten together. It was another site on the Coosa River. So much for the early Alabama attempt.

The CHAIRMAN. How does that water power compare in volume with Muscle Shoals?

Mr. LANDIS. Considerably smaller; probably not over 35 or 40,000 horse power, which also has an important bearing on the process, because that is one of the settings.

The CHAIRMAN. That is why I asked you the question, because I have understood from all of these witnesses that the arc process does require more power, and, of course, it would be perfectly natural with a small water power that a man would not recommend a process where there is only a capacity for a small amount of power.

Mr. LANDIS. That had a bearing on the situation; quite right, Senator.

Senator MCNARY. If you had had this water power at that time you might have changed the process?

Mr. LANDIS. No; as I shall show you later, even the hundred thousand horsepower at Muscle Shoals would not have reached the point where this thing would have been of value. I will bring that up later, and develop it.

The next attempt at introducing the arc process in this country was by Mr. James B. Duke, who had a very large power development in the Carolinas. He had a number of dams there which were built——

Senator MCNARY (interposing). Is that the man who makes Duke's Mixture?

Mr. LANDIS. Yes; the man the mixture was named after. He has there to-day something around 500,000 horsepower developed; but at that time not quite so much. There was no load for that power at the time it was put in. When you build a power plant you must build the whole dam, whether you are to use one horsepower or all the power that can be developed; so he had surplus power there at the start; and about 1908 he entered into negotiations with an arc process which was claimed to have the merits of being applicable to what is known as seasonal power, this secondary power which runs for six or eight months, or whenever it rains, you might say. He spent about $750,000 for that process, and erected the plant and brought over foreign engineers who had been associated with that arc process to erect this plant; and by the way, those engineers are still in this country. The first complication that he met was that as a matter of fact it was impossible to consider this arc process on seasonal power.

It is necessary in any process to have a market, and you must contract for that market; if you had to depend on displaying heavy chemicals on a shelf and sell them as the customers came there you would have an impossible situation in the chemical field. It is necessary that you be able to contract for materials. It was necessary to build a very expensive installation which could only operate over six or eight months, or possibly only two months, if it was a season that there was not much rainfall, and to carry that plant over the remaining time added a great deal of expense. However, he even went further than that, and proposed, about 1911, to add to that plant, which was done; and the reason for that addition was this: The first plant was installed for the purpose of making nitric acid. There was effective operation of it, under careful supervision, and yet he could not market the acid. It is a material that can not be shipped to any great distance, because of its corrosive quality, and South Carolina is a long way off from a point of utilization of nitric acid. He then turned to make fertilizer from this nitric acid, and built a plant two years after the plant in South Carolina was first put into operation, to make fertilizer. I do not think these things need go into the record, but if there is any question, I have here the newspaper clippings covering the whole situation down there.

The CHAIRMAN. Why did he not make them into solids?

Mr. LANDIS. He proposed to make fertilizer, which is a solid, and I have a sample of the product here [indicating]. He could not market that product, and that plant was then turned to make nitrate of ammonia and finally was abandoned about 1913. It has been started up twice since 1913, and ran two or three months at each time. During the war the price of nitric acid went very high; in fact, there were practically no quotations. They started up the plant, made nitric acid, put it into glass carboys and shipped it north at more than three times normal prices, which high price enabled them to operate. The first carload reached the railroad yards just outside of your city here, and during the shunting one of the bottles broke and the acid set the car on fire. When the second shipment was made the same thing occurred, and the railroads refused to take the third car, and they shut down. Nitrate of ammonia was then manufactured down there during the year 1915, and I believe, they made quite some quantity of nitrate of ammonia, until the supply of ammonia which they had available there was no longer available. I think it was diverted to other more efficient uses than he was making of it, and therefore the plant closed down again and it has been down ever since. I tried to learn just how much money had actually been put into that process down there, along with the original investment; but in the short time I have had it was not possible to learn that: but it is over $1,000,000 all told. To-day the plant is idle.

Now, the next attempt at the introduction of this arc process—Mr. Chairman, while this may not be interesting to you, I wish you would say so if it is not.

The CHAIRMAN. It is very interesting; go ahead.

Mr. LANDIS. The next attempt at building an arc process in this country was made in 1915. There was an attempt made to build a plant with a capacity of about 50,000 tons of nitric acid——

The CHAIRMAN (interposing). Where?

Mr. LANDIS. The site was not ultimately settled on, as I will explain to you. Engineers not connected with my company, not in any way connected with my company, were employed to design and estimate upon the cost of that operation, and the details given to them were that it was to be in New York State or Canada, and in the meantime the principals were negotiating for the necessary power, while the designing was going on. Those designs were finished in March, 1916. I happen to have a copy, which I was so fortunate as to obtain, of the detailed estimates for that plant. It lists every bolt and every nut and every piece of equipment in the place. For this plant there are also a large number of drawings——

Mr. SCOTT (interposing). I wish you would have them put in the record.

Mr. LANDIS. I beg to refuse, this being confidential information; I beg to request it be not included in the record.

By the time these estimates and figures were all completed the cost was so high for the installation of this process that the project was abandoned. That was in 1915, and that project was not even started.

The next attempt is rather an interesting one, and it is one that I believe will succeed. The most highly developed of the arc processes are those of Norway. They have nearly 400,000 horsepower in that. The Norwegian process is covered by a great many patents and rights and processes, and all of those patents and the rights and the processes have been sold to an American company, and that company has been figuring since 1915 as to how it could build an arc process plant, and they are to-day ready to go ahead with that as soon as the right conditions can be found.

Senator MCNARY. What is the name of the company?

Mr. LANDIS. Not being my own company, I would prefer not to say unless you insist.

The CHAIRMAN. Well, I do not know why there should be any secret about it?

Mr. LANDIS. Well, the Du Pont Co.

The CHAIRMAN. There is no crime in telling what you know about it.

Mr. LANDIS. I hesitate myself to speak about other men's matters.

The CHAIRMAN. Only as a matter of information.

Mr. LANDIS. Well, it was the Du Pont Co.; they own all of the rights of the Norwegian process——

The CHAIRMAN (interposing). That is in America?

Mr. LANDIS. In America.

The CHAIRMAN. They do not own it in Norway, or Europe?

Mr. LANDIS. No; only in America.

Senator MCNARY. That is, of course, the Du Pont Powder Co.?

Mr. LANDIS. Yes.. That company is not interested in fertilizer, but is interested in nitric acid. They have a place in the industry, and I believe when they can find cheap enough power—sufficient quantities of power, we will see an arc process plant in this country. It is the most ideal setting for it that we could have. It is what the arc process was designed originally to produce, and it is their best product.

Now, that is the history of the arc process in this country. It certainly has been given about as much chance to succeed as any process that I know of, and there certainly has been a great deal of money spent on it.

Senator MCNARY. On that point, if you would go out to the Columbia River you will find as high as 5,000,000 horsepower running to the sea. This thing is like a mill race as compared to that wonderful river. Why would not that be an ideal location for a plant such as you are now discussing?

Mr. LANDIS. It would be an ideal location for a plant for the manufacture of nitric acid if, after you had the nitric acid, you knew what to do with it. Unfortunately, there are no dye plants and no explosive plants, the two largest users of nitric acid in that region, and therefore you would have to put not only a nitric acid industry out there, but also a secondary industry that uses the product.

The CHAIRMAN. Of course, it could be used for fertilizer, because out there is where they have the rock.

Mr. LANDIS. I am going to take up that relationship in its own place.

Now, there is a plant in this country operating—I believe it is operating, although I myself am not familiar with it—at Seattle on water power. Mr. Chairman, that plant is making what is known as sodium nitrite. It is a chemical product that was on Saturday quoted at from 24 to 30 cents a pound in New York. In other words, from $480 to $600 a ton, and it has exactly the same amount of nitrogen in it as ammonium sulphate, 20 per cent. It would be rather an expensive fertilizer. That plant has another place which is quite logical; in other words, the only other source of sodium nitrite is either Norway or Syracuse, N. Y. They make it in Syracuse by the process which we could use in Muscle Shoals as well as in New York; the equipment is all in the Muscle Shoals plant, but we must rearrange some of it to make that product. The freight rate on that material from Syracuse to Seattle is, roughly, about $25 a ton. The market for that material is Japan, and at Seatle they have, you might say, directly a subsidy of $20 to $25 or even more a ton; freights may increase on their product with additional advantage over the man in Syracuse, N. Y., who is manufacturing that product. Naturally that plant with a site like that, may operate—I am not prepared to say whether it is operating. But that is a special case which you could not afford to consider as a fertilizer situation, with a price of material at $600 a ton, when you could replace it with nitrate of soda or sulphate of ammonia with one-eighth of that cost for the same amount of nitrogen.

Now, Mr. Chairman, there are some unfortunate——

The CHAIRMAN (interposing). What is this nitrite used for?

Mr. LANDIS. It is used in the dye industry.

The CHAIRMAN. Well, I was going to suggest also, would it not be very practical and very necessary to try to find some plant to manufacture nitrite, and make it cost a whole lot less than it does at this particular time?

Mr. LANDIS. Mr. Chairman, nitrite is a by-product of the large arc process plants in Norway; they can deliver it at almost any cost—you know the cost of ocean freights are very low coming this way, and that hinders American industry; nevertheless, there is a very large factory equipped at Syracuse, N. Y., to make nitrite from coke oven ammonia, by burning the ammonia, just as the Muscle Shoals plant does, and absorbing the gases in the corresponding sodium compound. I have been in that plant and seen it operate. I presume it is operating to-day, but I have not seen it for some months. You have here a direct competition of the coke oven again, or you have direct competition with Norway with freight rates as low as four to five dollars a ton coming this way for a by-product from there; and secondly, there is very little of that material used in this country, at most about 5,000 tons.

The CHAIRMAN. But there is a very large amount of material used and bought by the public which, if they had this process in this country——

Mr. LANDIS (interposing). For nitrite?

The CHAIRMAN. I mean the dye products; and it is not by any means a small question. Pardon me for making this interruption, but I had a manufacturer from Pennsylvania, a silk manufacturer, call on me not long ago, and he gave me the history of that—of what we are trying to do here in Congress just now. The fact of the matter is that we do not know how to figure the percentage high enough to keep the stuff out, as far as percentages go. They are at a loss, anyway, for figuring it out. Now, it seems to me that all these things have their proper use; and while I belong to a party which has always stood for protection to infant industries, I doubt if I would want to go to the extreme of subsidizing, I might say, any industries just to keep the foreign article out when, as a matter of fact, it is not practical to produce it in our own country. Now, the question is this: If by a new process we could manufacture this——

Mr. SCOTT (interposing). As a by-product?

The CHAIRMAN. As a by-product, and compete, why not do it?

Mr. LANDIS. You practically have that situation to-day existing at Syracuse, where the by-product is being converted into this sodium nitrite by a process that is quite practical. The quantity used is not large. I believe the world uses about 9,000 tons; in this country—I do not know, but I should judge, roughly, three to four thousand tons used per year.

The CHAIRMAN. Yes; but that is $5,400,000.

Mr. LANDIS. For the world's business. As an industry, we look upon that as small from an international standpoint, taking the world as a whole. But you have a plant in Syracuse, N. Y., capable of making that material, and so doing; also you have an arc process plant in Seattle which is a very fine proposition, I believe, because they have everything there—cheap power and high competing freight rates against their nearest competitor for protection and an excellent situation with respect to Japanese export. It is perfectly proper for the arc process; but I would not want you to get the idea that that would be a fertilizer situation out there, because that would change the situation entirely if you attempted to make cheap fertilizer.

Now, there were some unfortunate references here to personality and the nitrate industry. I would like, Mr. Chairman, if I may, to review this nitrate industry and particularly correct some of the information which I fear was not quite—possibly has not quite given you a true picture.

The cyanamid process, as mentioned before, was developed by two Germans. They sold their rights—after they could not develop the process to commercial success in Germany they sold those rights. It is rather interesting to think that the Germans failed on a German chemical development; but they could not commercially develop the cyanamid process in Germany, and they sold those rights to an Italian company; that is one thing that got away from the Germans in the chemical line. And the Italians succeeded in reselling those rights to various parts of the world; for instance, they sold rights in England, they sold rights in America, and they sold them in Japan, in Italy, in Dalmatia, in Germany itself, and in Austria; cyanamid factories are distributed practically all over the world.

The CHAIRMAN. Well, I said a moment ago that I thought it was an Italian discovery. I remember very well a statement on Saturday that the company owning these patents is an Italian institution, and that you people are all operating by virtue of a license. Is that correct?

Mr. LANDIS. That is correct; the American Cyanamid Co. had transferred to it for a cash sum of money the United States patent that applied to the cyanamid process. The various other companies have some more complicated relationship, as for example the English companies, with its headquarters in England, but it operated in Norway and Sweden—now alone in Norway. Now, there is absolutely no relationship between any of these cyanamid companies——

The CHAIRMAN (interposing). It makes you competitors rather than associates?

Mr. LANDIS. For instance, there is not a stockholder on our list, that I can find, that owns stock in the English company, and as far as we know there are no English stockholders who own stock in the American company. The Japanese have nothing in common with the rest of the countries.

The CHAIRMAN. Well, you have no interest in each others companies nor in the product you produce? The only interest you have in common is the sympathy which you have for the particular process? You believe in the cyanamid process; is not that really the case?

Mr. LANDIS. I was just going to state, in 1914 the cyanamid industry faced a very peculiar situation. There were large quantities of ammonium sulphate coming into the market; prices dropped very low, to the lowest price I know of that sulphate ever sold at. I wish I could go into the economic condition of that, but it would be too long a story. The cyanamid industry throughout the world was so affected by this ammonium nitrogen coming on the market in direct competition with their own product, and the situation seemed so serious that the Italian holding company called a conference to be held in the interest of all the manufacturers of cyanamid to discuss this situation and see what could be done to save their industry.

The CHAIRMAN. Would not that indicate that the statement which I made—if I made it clear to you—was the whole idea, sympathy in the process?

Mr. LANDIS. Exactly so. Unfortunately, there are a great many differences between the various cyanamid companies, and that conference resulted in absolutely nothing. In 1919 we were faced with a situation that Mr. Washburn so ably presented to you, of coming out of the war with an enormous surplus of nitrogen—whether it is nitrate or sulphate or Haber ammonia does not matter, it was nitrogen of some kind or another. At that time there was a conference called to catalogue the kinds of quantities of nitrogen that might be available. Naturally, by bringing in the representatives all the way from Japan, France, and England they were invited, and from America and Italy, bringing together representatives of the prominent nitrogen industries in this country, we would be able to learn how much nitrate, nitrogen, we should expect from Norway, how much ammonium nitrate we could expect—and we had very good information on the Haber process, because the Germans had just sold the rights of the process to two European countries and laid the cards on the table, which——

The **Chairman** (interposing). What countries were those?

Mr. **Landis.** Italy and France.

The **Chairman.** What year was it they sold those patents?

Mr. **Landis.** 1919; it was after the war. That conference developed the fact that we were up against a serious situation in the cyanamid industry, in the fact that the prepondering fixation plants that had been built during the war were plants capable of producing ammonia and ammonia compounds. There was not as much development in the cyanamid—I will not speak in exact percentages—as of some of the other processes; but the ammonia situation appeared to be rather serious for the cyanamid companies and we had a conference there. Even the nitrate of soda people appeared in that conference, which may seem a very strange thing, but the nitrate of soda people were also in search of information as to the oxidation of ammonia to make nitric acid; naturally they were interested in that phase of the cyanamid situation. That conference broke up without any permanent result whatever. There just happened to be so much friction between the various cyanamid companies in the countries that nothing could be accomplished at those conferences.

The **Chairman.** Am I correct in assuming that this product, this compound, rather, cyanamid, has been used for explosives?

Mr. **Landis.** Mr. Chairman, you are not exactly correct in that statement, if we consider the history of the cyanamid process. Cyanamid itself was designed originally by its inventor to be a fertilizer for direct application to the soil. It developed limitations—Mr. Washburn has expressed those—in a ton of a mixed fertilizer you can put in so many pounds of cyanamid, and then you must stop. In all the various countries there were certain limitations existing, but not to the extent of quantity, because the mixed fertilizer in Europe is not very extensively used, and cyanamid found a slightly increased usage in Europe by virtue of the fact that it itself could be strewn on the ground without mixing. It, however, did get into serious difficulties over there by virtue of its corrosiveness to the skin, the hands, and to horses, so that cyanamid itself only partly satisfied the needs for a direct fertilizer. It was then converted into ammonia compounds, and there were processes in Germany, in Italy, in France, and in Japan, just prior to the war, for making ammonium sulphate from cyanamid. We ourselves had the same thing in operation in this country; we made ammonium sulphate in order to use more than as direct fertilizer. We soon had to get out of the sulphate business. Cyanamid itself, therefore, has only received partial development as a direct fertilizer; it has been transformed into other compounds very largely.

The **Chairman.** Do you make what we call formaldehyde out of cyanamid?

Mr. **Landis.** Not that I know of.

The **Chairman.** Do you know that there is a very large use for formaldehyde? In fact, it can hardly be purchased. We use it by the tons out in my country.

Mr. LANDIS. A great many things can be made out of cyanamid; now, formaldehyde can be made out of cyanamid, but it is not a commercial process to-day; and my reference to those things—what to-day is not commercial may be to-morrow. We have not put any effort on formaldehyde, as we have been busy along other lines.

Now, I trust that gives you some idea as to the relationship of cyanamid companies; they have been at odds with sulphate of ammonia producers ever since the cyanamid process started, because these are direct competitors; they have been at odds with themselves for many various reasons. One is that some companies outstrip the others in ability to increase production and efficiency, and that happens to be the unfortunate situation of the American Cyanamid Co. Now we are disliked by everybody.

The relationship was brought out of a Mr. Barton, which I did not like, because I did not think it was fair to Mr. Barton, who was not here to defend himself; and if I may, I would like to put a statement in the record concerning Mr. Barton's relationship with the cyanamid company, knowing Mr. Barton myself.

The CHAIRMAN. Is he an American citizen?

Mr. LANDIS. He is not; he is an Englishman; but his name was mentioned in a very uncomplimentary manner.

The CHAIRMAN. Well, of course, as far as I am personally concerned, I have no objection.

Mr. LANDIS. It will give you some history of the English Cyanamid Co., which also may be of some interest to you.

The CHAIRMAN. I take it that you will only make a brief reference?

Mr. LANDIS. Yes. The English Cyanamid Co. was largely owned by the Vickers Co., and Mr. Barton was the older Mr. Vickers's personal representative on the board of the English Cyanamid Co., and it is hardly likely that Mr. Vickers would put in that position a man characterized as unfairly as Mr. Barton was characterized yesterday.

(Whereupon, at 4.30 o'clock p. m., the committee took a recess until 4.45 o'clock p. m. to-day.)

AFTER RECESS.

At 4.45 p. m. the committee reassembled pursuant to the taking of recess.

STATEMENT OF MR. WALTER S. LANDIS—Resumed.

Mr. LANDIS. As I was saying, the Vickers Co. were interested in this English Cyanamid Co., and Mr. Barton was the representative on the board of the older Mr. Vickers. That company arose in this way: The Vickers Co. bought the Alby Carbide Co., in Norway and Sweden, being users of calcium carbide in their steel works and shops for making acetylene gas, and they formed what was known as the Alby Carbide Co. The cyanamid process came along, and they bought the license from the Italian company to manufacture cyanamid, and they formed a company known as the Northwestern Cyanamid Co. to make cyanamid, and that plant is located, with a different office and different manufacturing plants entirely, in the same town as one of the plants of the Alby Carbide Co. namely, Odda, Norway; but they are entirely separate companies. The

English company has quite a commercial proposition in selling cyanamid, as it has an essentially export business. Only 7 per cent of the land area of Norway is available for agriculture, and Norway uses, in tons, a comparatively small amount of fertilizer, and, it being a cold, far northern country, wants as much nitrate as it can get; it is too cold for the use of ammonia compounds, and they want nitrate compounds. They have always imported them from Chile or manufactured them in their own country. Cyanamid, therefore, was an export proposition, and they export all over the world to various countries, and they therefore formed the Nitrogen Fertilizer Co. (Ltd.) as an exporting and distributing company for fertilizer, and that is the relationship which, I fear was very much tangled up as a stock-jobbing proposition by Mr. Scott, when it is really a logical development. Now, Mr. Barton is not connected at the present time with that institution in any way, and has not been for more than a year; so this name I do not believe should have been mentioned in any such manner as it was.

Now, Mr. Chairman, I would like to go on the Muscle Shoals plant and the arc process and give you such facts as I can give you with respect to a proposition that I have been studying for some 12 years. Now, the arc process requires, as measured actually by myself in certain plants, and according to data obtained from engineers in other arc-process plants, about 12 horsepower running for a whole year to put a ton of nitrogen into a chemical compound. However, this report says there is a possibility of some improvements. Now, I have not direct knowledge of whether such improvements have been made within the last two or three months, but I do know that all the suggestions in that report have been tried out at various times in the last 15 years without resulting in any commercial application of them. They are complicated, and sometimes you can overload your process with too much complication; and so far none of these suggestions have made any headway, although they have all been tried out. But I am going to assume, for the purposes of giving you simple figures—let us call it 10 instead of 12 horsepower, because we can divide by 10 easier than by 12.

The CHAIRMAN. Do you intend to make a comparison as you go along?

Mr. LANDIS. I intend to show what the Muscle Shoals plant could do if it were an arc-process plant, and will give you comparisons right along.

Now, the present plans for the power development down there include the installation of electrical machinery in this dam that is now before us, for generating about 100,000 horsepower. I have no dispute to offer on that score.

The CHAIRMAN. Will it interrupt you if I ask you a question? Mr. Bowers stated that he thought you could develop a maximum of 200,000. As an engineer, do you agree to that?

Mr. BOWERS. Mr. Landis, to answer that question—what I was driving at in 200,000 horsepower—now, I am not an expert on this; it is just what has been explained to me.

The CHAIRMAN. We understand that; but I would like to get his judgment as an engineer.

Mr. BOWERS. Now, the 200,000 horsepower include the utilization of the Muscle Shoals steam plant.

Mr. LANDIS. That situation is this way: The dam to be built at Muscle Shoals generates power by virtue of the water flowing through a waterway; now, if you have a rainy season you have lots of water; if you have a dry year there will not be so much water, and you will not get so much power.

The CHAIRMAN. Of course, I had reference to normal conditions. My question was also directed to water power exclusively. Of course, if we had enough coal, and large enough machinery——

Mr. BOWERS (interposing). The point there is, with that steam-power plant right there—you know the engineers have studied Muscle Shoals for a long time——

Mr. LANDIS (interposing). For 44 years.

Mr. BOWERS. Yes. For 44 years they have studied the rainfall and the water in the river, so it is not a guess as to what the average amount of water will be; it has been definitely established by 44 years' measurement of it. Now, what hydroelectric engineers, as I understand, consider as primary power—you take nearly all these big hydraulic installations and they have steam auxiliaries; it is all hydraulic, but part is steam auxiliary. Now, Muscle Shoals has undoubtedly got a hundred thousand primary horsepower that does not require any steam at all. Then they figure, as I understand it, and I want this cleared up carefully, and I think the Corps of Engineers are the proper people to do it—an additional 100,000 horsepower that can be made by using that steam plant.

The CHAIRMAN. Mr. Bowers, I was asking a question for information I want to get from Dr. Landis.

Mr. LANDIS. I understand what you ask——

Mr. BOWERS (interposing). And I want you to answer in that light.

The CHAIRMAN. Well, I wanted him to answer the question, if he will, the way I put the question.

Mr. LANDIS. I think I will answer it, but I am going to put some limits on that——

The CHAIRMAN (interposing). My desire is to find out how much water power can be developed at Muscle Shoals. I am not going into the merits of one process or another; just for information, just for the record, that is why I am asking the question. What is the possibility? What is the maximum power that can be developed, taking normal conditions, at Muscle Shoals? That is really what I intended to ask.

Mr. LANDIS. There are records of the amount of water flowing in the river covering a period of 44 years. In those 44 years there was one year which had an extremely low rainfall; lower than any of the other 43 years, and materially lower. During that year, for about two weeks, the amount of power that could have been developed at Muscle Shoals by water power only would have been about 70,000 horsepower; but for the other 43 years I think we are quite safe in taking 100,000 horsepower as being available all the time.

Now, Senator, it is not necessary for a manufacturing plant to have power every hour of every day, and every day in the year. There is no plant that does not break down some time or another; your own city electric-light plant here breaks down once in a while; your manufacturing plant breaks down, and these periods of short power can be used for cleaning up and making repairs.

Senator **Kendrick**. So if there came a time, an extreme situation, in which there was less than sufficient power it would not necessarily mean that the plant was a failure?

Mr. **Landis**. Absolutely no. So, if you run along for, say, seven years—that is about the cycle of low water in that territory, and then every 28 years you get a year considerably lower water than the other 28—that is very well defined, and, now, if you run along for six years at 100,000 horsepower all the time, and the seventh year you went down to 70,000 for two or three days during the year, you could afford to shut down your plant and clean it up. That is something you must count in your cost of operation, in any event. At Niagara Falls, where we use only 5 per cent of the power going over the Falls, we have interruptions from other causes, and we use those times to clean up and make repairs. It does not spell failure of the cyanamid process if the power is off for an hour or two or three.

I think that answers your question about power. If you desire to shut down for two weeks, and it does not interfere with your process, then you can have more than 100,000 horsepower for the other 50 weeks.

The **Chairman**. I take it it would be difficult for you to get through to-day.

Mr. **Landis**. I would like to have a little more time.

(Whereupon, at 5 o'clock p. m., the committee adjourned to meet at 10 o'clock a. m., April 13.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

TUESDAY, APRIL 13, 1920.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met in the hearing room of the Committee on Manufactures, in the Capitol, at 10.30 o'clock a. m., pursuant to adjournment on yesterday, Senator Asle J. Gronna (chairman) presiding.

The CHAIRMAN. Mr. Landis, you may proceed with your statement.

STATEMENT OF DR. WALTER S. LANDIS—Resumed.

Mr. LANDIS. Mr. Chairman and gentlemen of the committee, I believe that we were discussing last the question of the amount of power that could be developed down on the Tennessee River, and I think we agreed——

The CHAIRMAN (interposing). At Muscle Shoals?

Mr. LANDIS. Yes, sir. We agreed that the proposed dam down there would generate 100,000 horsepower and, as far as I know, for commercial considerations attention must be given to putting a load of that quantity on it.

The next matter we were taking up was the proposal brought up by Mr. Scott, that the arc process be installed at Muscle Shoals, and I referred to the fact that measurements made by myself and by other engineers and with which I was in touch showed it took about 12-horsepower running for one whole year, 24 hours a day and 365 days in the year, to fix 1 ton of nitrogen by the arc process. That figure varies slightly with the different modifications of the process, but it is a good representative figure. The English report referred to by Mr. Scott and which I will discuss a little later on shows a figure of approximately 11 horsepower. But discounting those figures for possible improvements which may have taken place within the last few months and that I am not familiar with, let us call it 10 horsepower. That is 20 per cent less than the measured figures I had, but it gives us an easy figure to work with.

Now, on the generation of 100,000 horsepower at Muscle Shoals, and taking 10 horsepower for the whole year to fix 1 ton of nitrogen, that power plant down there would give us 10,000 tons of nitrogen. The Muscle Shoals plant, according to the test records which the Ordnance Department seems to agree with in every respect, shows that with the cyanamid process installed down there—the present cyanamid process—and with 100,000 horsepower we could fix 45,000 tons of nitrogen. That is, with the same power. In other words, it would give four and one-half times as much.

As a matter of fact, if we consider that the mere fixation of nitrogen without getting it into a fertilizer product has no immediate interest; and we turn it into the fertilizer product, where we lose a little bit of nitrogen that we put into the first chemical combination, it will actually give us 9,000 tons of salable nitrogen in the form of fertilizer products, or about one-fifth as much as the present process that is installed at Muscle Shoals with the same amount of power. That is a rather interesting comparison of the two processes. It shows how much you would decrease the capacity of that plant to make fertilizer if you attempted to use the arc process.

The **Chairman.** How much could you manufacture with the other process?

Mr. **Landis.** The arc process?

The **Chairman.** No; the other.

Mr. **Landis.** The rated capacity of the Muscle Shoals plant as it was completed and as it stands to-day down there was 45,000 tons of nitrogen.

The **Chairman.** Well, by the use of the same power and the same formula and the use of everything the same as you figure out by taking the arc process, taking the same conditions exactly as you describe, how much could you produce by the cyanamid process?

Mr. **Landis.** Forty-five thousand tons of nitrogen. That can be expressed, Senator, as you understand, in various compounds, but as to cyanamid fertilizer it would be 220,000 tons.

The **Chairman.** I understand that, but you would manufacture nitric acid by the arc process. That is what you would manufacture with the arc process, nitric acid. Now, take the same compound and how much would you manufacture by the cyanamid process?

Mr. **Landis.** Four and one-half times as much.

The **Chairman.** Of exactly the same compound?

Mr. **Landis.** Yes, sir; four and one-half times as much of exactly the same compound.

Senator **Kendrick.** At what proportionate extent?

Mr. **Landis.** I did not catch that question?

Senator **Kendrick.** At what proportionate cost?

Mr. **Landis.** I would like to defer that for one moment as we will take up costs as a separate item.

Senator **Kendrick.** All right.

Mr. **Landis.** The first thing to consider about the plant, as Mr. Scott said, is that it is not adapted in any particular to the arc process. It was not built for that process, and outside of a few buildings and possibly some very, very small amount of equipment, you would have to put in entirely new equipment, at very high cost, as I will show later.

Let us see what the arc process could do for the fertilizer man: I have here a sample of the fertilizer product which is made at the Norwegian plant. This is what is known as nitrate of lime. It has some rather interesting properties. This came from Norway, and so far as I know this bottle has only been opened once before, about the time I obtained it. It is a product that, first, contains only 13 per cent of nitrogen in the form of nitrate nitrogen. Chilean nitrate has

16 per cent. It requires the shipping of more inert material to get a ton of this to the farm than even of nitrate of soda because of its lower nitrogen content. This particular sample contains 13.1 per cent of nitrogen.

You will notice that this material in the bottle is hard and caked. That is an unfortunate property of the material, because as a fertilizer it is an excellent material, but it has unfortunate mechanical properties; it is very hard. You see, I have to dig and cut to get it out of the bottle. That material also has another unfortunate property: Take a little bit of it—and I will close the bottle up quickly, to keep that left in the bottle from taking up moisture from the atmosphere. Now, you will notice how that material has gotten wet from drawing moisture from the air, and you will see how it is getting wetter and wetter every minute. That is what is known technically as a hygroscopic property. I will throw that away and take a little more out of the bottle and show you again how quickly it becomes moist. It is so hard in the bottle that you have to dig it out, but when you get it out where the atmosphere has free play you notice how quickly it gets wet. It cakes and plasters together. It is that very unfortunate property of sticking and getting wet that I am now calling your attention to. If that bottle were left open, or the contents of the bottle were spread out on the table, it would not do it quite as fast as I show you on my hand here, because I am rubbing it and exposing it to the air all the time to illustrate how quickly that property shows itself. But in about a day you would find it would go into solution, even if lying on a piece of paper in the room; it becomes wet, a liquid mass.

That brings up the question as to what can be done with that material if you had it? And what is being done with it where it is manufactured or used. First, it can not be shipped in sacks or bags. It can not be shipped in what is known as porous barrels; a sugar barrel, for instance. It must be shipped in casks or tight barrels. And when you open such a cask you must use the material immediately upon opening and must apply it directly to the soil. Now, that is impracticable in the shipping and using of fertilizer—to apply by hand directly to the soil until your barrel is entirely used up. If you were to mix that with other materials in a fertilizer plant and let the mixture stand around a damp day like yesterday or during a shower that material would immediately draw in moisture from the air and get wet and cake solid. And in that solid and caked form, of course, it is quite out of the question for the American farmer to use, because he drills the most of his fertilizer, and I think one of the most serious properties which a fertilizer could have is that of caking, because the farmer is not interested in having a bag of hard, lumpy fertilizer come to his farm and attempt to feed it through our ordinary fertilizer drill or fertilizer distributing attachment. The result of that is that there is little or none of that material that ever finds its way into the mixed fertilizers which form the bulk of the fertilizer used in our country. But it has been used abroad where they distribute nitrate or nitrogen compounds one time and phosphate or potash compounds another time. As to the question of the use of it in England by the Belgian refugees, that is quite natural.

The Belgian refugees farm what might be called small gardens. I have spent months in England and am quite familiar with that situation. It is quite a different problem in the case of a man with a little back yard or a garden or even a plot out on the common somewhere to distribute this material by hand, but if you had to distribute it in our large fields in this country, in some cases a 100-acre or 500-acre or perhaps a 1,000-acre wheat field in the West, it would be an impossible proposition. Here where large-scale farming is done they use mixed fertilizer in the machine with seeds, and the fertilizing and the seeding is all done at one and the same operation.

I think that distinctly shows that this is not a material which is adapted to American conditions, but I would like to cite still another bit of information in connection with this matter: Some years ago about 5,000 tons or 10,000 tons of this material was sent from Norway over to the United States, and the Norwegian company established an agency in New York. It conducted very extensive advertising and very extensive propaganda work. The most of that material, I believe, was given away in order to introduce it. I had a barrel of it sent to me. I know that Mr. Washburn had two or three barrels sent for his place. We all had the same unfortunate experience with it—that we would open a barrel and take out the first lot, which was quite granular and easy to use, and then come around the next day in order to make a second use of it and find the barrel was nothing but thick soup or paste and the material entirely unusable.

These facts are borne out by literature and publications. I do not like this proposition of reading a sentence or a phrase or even a few words out of a publication. I do not think that conveys a general idea of what information there is in a publication. For instance, I could read out of this publication of about 300 pages almost any information I desired to convey, if I were to select merely a sentence, phrase, or a few words. But this is a matter, I think, of very common knowledge.

The CHAIRMAN. You are speaking of nitrate of lime?

Mr. LANDIS. Yes, sir.

The CHAIRMAN. What about it when manufactured into a form know as saltpeter?

Mr. LANDIS. That is commonly known abroad as Norwegian saltpeter.

The CHAIRMAN. That is another name for it?

Mr. LANDIS. Yes, sir; they call it Norge saltpeter.

The CHAIRMAN. Isn't it manufactured in a different form also over there?

Mr. LANDIS. I know of no other form than that in which it occurs as fertilizer.

The CHAIRMAN. That is the only form in which it can be made with that process?

Mr. LANDIS. They have gone through very many years trying experimental work and that which you have there simply represents the product they were turning out last summer. I have samples of that material up through, I should say, eight or nine years of experimentation. I have great numbers of those samples and they have changed but slightly, and this is supposed to be the latest improved form. The earlier forms were still more troublesome from this hygroscopic property than this. This is what is known as the basic nitrate, which is supposed to be much less hygroscopic than the earlier forms, which were crystalline nitrate somewhat looking like crystalline salt here in another bottle.

However, the Smithsonian Institution has reported upon properties of this material, in which they agree absolutely with what I have told you. The Ordnance Department have also reported in your testimony essentially the same thing. But I thought it might interest you to have an actual sample to see just what it does. They have a great deal of difficulty in marketing it. I have here an article which has the startling heading, "Nitrate of lime warning." It shows how an unscrupulous dealer in making use of that hygroscopic property by letting that material take up a little water—and of course it weighs more—will sell the water at the price of nitrate. It tells the farmer to test it on receipt so that he may not be done out of the added weight of water for the price of good nitrogen. It is a property that is unfortunate for the material and it has led to a number of unscrupulous practices in certain directions.

Senator **Kendrick**. It is your contention that this material would be impracticable for sale and distribution in this country?

Mr. **Landis**. Absolutely. And I am putting that information before this committee because I believe that it should be made use of in order that you may not go to any extent into something that has already been commercially demonstrated as not usable in this country.

Senator **Kendrick**. Wouldn't it be highly useful in truck gardening?

Mr. **Landis**. It is an excellent fertilizer.

Senator **Kendrick**. I believe Mr. Scott testified that it was even better than nitrate of ammonia; that it is better than this other sample you have here, in that it has a tendency to sweeten the soil, while the other, as I understand, brought the soil into an acid condition.

Mr. **Landis**. I should say that it was at least as good as nitrate of ammonia for nitrate applications. However, some plants do not thrive as well on a straight nitrate application as they do on a combination application.

Senator **Kendrick**. Is this a by-product of the regular manufacturing plant or is it the primary product?

Mr. **Landis**. The arc process plant was erected in Norway for the purpose of making nitrate acid. It is almost impossible to ship nitric acid from Norway, because it requires exportation and sea haul, and the problem of containers is very difficult. When they found that they could not market nitric acid as such commercially, they turned to the marketing of the solid product, which could be shipped in casks, and, therefore, this really represents the bulk of their peace-time production; it is a direct primary product and the bulk of their peace-time production.

Senator **Kendrick**. Would that prove the principal product of manufacture at Muscle Shoals under our present cyanamid process?

Mr. **Landis**. It would not. There has been no mention whatever made of making this material at Muscle Shoals from the cyanamid plant down there other than by Mr. Scott.

Senator **Kendrick**. Is there any plant in the country manufacturing that product at this time?

Mr. LANDIS. There was a plant at Notrolee, S. C., that in 1912 attempted its manufacture. But they could not sell the product, and abandoned it within a few months after starting. There is no plant to-day that I know of making that product.

Senator KENDRICK. Isn't it true, then, that even if we did manufacture this product on a moderate scale, we will say, at Muscle Shoals that there would be ample outlet for it in truck gardening in the country?

Mr. LANDIS. I should say not, judging from the experience had with the importation of from 5,000 to 10,000 tons of that material, which they could not get rid of, except to give it away, some time back.

I think I have covered the use of calcium nitrate and shown that you can only obtain about one-fifth as much nitrogen from the Muscle Shoals power plant if you use the arc process as you could if you used the cyanamid process.

Another proposal has been made, to use ammonium nitrate made in the following manner: The arc process is to produce nitric acid, the nitrate part of ammonium nitrate. And the cyanamid process or the Haber process or the coke ovens are to furnish the ammonia part of that compound. Nitrate of ammonia is a most excellent fertilizer; there is no question about that. It has shown excellent crop results in the Rothampstead experiment station; in fact, I should say that the crop results were as good as from any conceivable inorganic nitrogen fertilizer. It, however, has the same disadvantage that you have in calcium nitrate. First, the material cakes. I have a sample here of ammonium nitrate made at the Nottoden plant by the Birkeland and Eyde process, which shows how that material has set up and caked in the bottle. It is extremely hygroscopic, just as you have in the nitrate of lime.

I have also here a sample of the improved form of nitrate of ammonia which came from abroad. That is a hard, lumpy material. I obtained that from the E. I. du Pont de Nemours Powder Co. One of these materials is a crystalline product such as is used for fertilizer, and the other is a grain product such as is used in explosives, but both have identically the same fertilizing value. The hygroscopic property of these materials is an unfortunate one, again, from the standpoint of mixing them in fertilizer. The bags set up hard, cake; they get damp, and the material gets lumpy, so that it will not go through a grain drill, and yet they have worked for a long time in the attempt to remove these properties.

Mr. Scott called attention to a publication by Dr. Russell, director of——

The CHAIRMAN (interposing). Before you go into that I want to ask you a question: You explained that this sample contains 13½ per cent of nitrogen. How would a ton of this compare with a ton of cyanamid; or, we will say, a pound of cyanamid, or you can take any unit you like?

Mr. LANDIS. It would take very nearly 2 pounds of that material to have the same content of nitrogen that cyanamid would have—not quite 2 pounds, but I will say 1¾ pounds, say. Cyanamid as made to-day at Niagara Falls runs about 21 per cent nitrogen, and it would take 1¾ pounds.

The CHAIRMAN. That is speaking of nitrogen only. What other compounds does this sample have except nitrogen?

Mr. LANDIS. The fertilizer value as determined by the experiment stations which valuate fertilizers, setting, you might say, the basic value of fertilizing ingredients in them, would give no credit to that material for anything except the nitrogen content, nor would they give anything else——

The CHAIRMAN (interposing). So the only thing we can consider is the nitrogen?

Mr. LANDIS. Yes, sir. They give so much value for nitrogen and phosphoric acid, and so on, and no matter what else you might have there they give no other value to it. As a crop-raising material there is no comparison that you could make between cyanamid and nitrate of lime that would be more than of the most general character, because one is nitrate nitrogen and the other is ammonia nitrogen, and they perform entirely different functions in the soil.

The CHAIRMAN. And you would have to mix them with different ingredients in order to make fertilizer?

Mr. LANDIS. The theory of feeding a crop is somewhat similar to the theory of feeding a man; it means something for breakfast, something for dinner, and something for supper. That is exactly the same thing in the feeding of a crop; it means something that is valuable when the seeds begin to sprout, and you want something to carry them through the growing season and the blossoming season. And if that growing season is prolonged, like cotton, you may want something to carry them even beyond and into the final curing season. Now, nitrate nitrogen has probably exhausted itself in about six weeks from the time it is applied to the soil. It is what is called a quick-acting fertilizer. Ammonia nitrogen takes about three weeks to be transformed into the form that the plant can take it up and it runs along some three months. Ammonium sulphate has been said to be active for about eight weeks' growth of a plant starting three weeks after you apply it. Organic materials like blood and tankage and cottonseed meal will run even as long as 120 days of active plant feeding.

Most fertilizer is always mixed up, if it has the base of nitrate nitrogen to start with; they always mix these fertilizers up with nitrate nitrogen, ammonium nitrogen, and in most cases even with organic compounds, because they last longer than ammonium nitrogen. They are thus giving a plant its breakfast, dinner, and supper by continuing the feeding process through the growing season of the plant.

The CHAIRMAN. You have no trouble with cyanamid in the way of caking, have you?

Mr. LANDIS. Absolutely not; unless it gets actually wetted mechanically by turning the hose or letting it rain on it, it will not lump up. It is stored in our factories in large heaps at Niagara Falls, which is a fairly damp climate; it is stored in large heaps there throughout the whole summer.

The CHAIRMAN. Do you put it into bags?

Mr. LANDIS. We put it in the bags as we ship it. It is not caked nor is it lumpy in any way whatever.

Mr. SCOTT. May I just say a word there: As to your inquiry about calcium nitrate and cyanamid, and Mr. Landis's reply that 2 pounds of one is required as against the other, let me say that all fertilizers are sold on the basis of nitrogen content, and, of course, one that has a lower amount of nitrogen is about half the price of the other. They are sold purely on the basis of their nitrogen content.

Mr. **Landis**. I think I have explained that.

Mr. **Scott**. I have just one remark more, and that is that the calcium left in the soil by a certain quantity of calcium nitrate is more than is left in the case of cyanamid. A quantity of cyanamid put in the soil would mean that you would have carbon and also calcium left in the soil as lime. The sweetening effect on the soil is greater in the case of calcium nitrate than in the case of cyanamid, ton for ton.

Mr. **Landis**. Qualitatively, that is correct. But Mr. Bower, who is here, is a better farmer than I am, and in this respect knows more about it. He will correct me if I am wrong, or, at least, will state the situation correctly if I fail to do so—that when you add lime to the soil you do not add it in a few pound lots to the acre, but put it on in ton lots. For instance, in the application of limestone as such you would put 3 or 4 or 5 tons to the acre. When you add nitrogen fertilizers you add only a few pounds, the average fertilizer application in this country; and quite a heavy application would be 300 pounds of fertilizer to the acre, which would have in it considerably less than 50 pounds to the acre of this nitrate of lime, for instance, or such materials. The result is that the lime addition you get from fertilizers is infinitesimal as compared to what you would put on if you were making a lime addition to the soil. But I think Mr. Bower would be more competent to speak on that than I am.

Mr. **Bower**. That is undoubtedly true. Its value as measured in dollars and cents in sweetening effect on the soil in an average application of fertilizer would be almost impossible to estimate. The standard practice in Virginia for an initial application on land that has no lime is 4 tons of ground limestone to the acre. That is, on the first application, followed four years later with 2 tons to the acre. If you use burnt lime you cut that in half and get the same result.

Mr. **Landis**. I was substantially correct, that there was such an infinitesimal addition of lime if you were really making an addition of lime that it is not to be compared.

Mr. **Bower**. Yes; you could not figure the money value to the farmer in its effect on the land.

Mr. **Landis**. Mr. Scott referred to the Rothampstead experiment station as to utilization of left-over munitions. All munitions are nitrate compounds, and some powders make most excellent fertilizers, some have actual nitrate in them; but not all of them. They have attempted in England to develop fertilizer uses for these left-over explosives and one of them had large quantities of ammonium nitrate. I want to say that Dr. Russell, whom I have known for some time and a very fine gentleman, showed me his test plats, small plats of a few hundred square feet, where he was having these fertilizers used. He spoke very favorably of ammonium nitrate as a fertilizer, but his great difficulty was, and he called particular attention to the fact is his publications, that it is used largely as a top dresser and applied alone, that is, by hand on the plants and without mixture. He says, however, if any mixing is attempted it must not be stored as the material cakes up. In case it is so used you get into trouble by its giving off nitrogen in brown fumes, which eats up the bags. In particular he mentions the fact that it is a most difficult material in order to keep the mixture in a mealy and granular condition so that it will go through the drills.

He made one statement that was rather unusual and that noted a fatal poisoning effect that they have had from mixing nitrate of ammonia with acid phosphate—giving off this reddish brown gas of nitric acid and actually poisoning with fatal results. He called attention to it in his publication, which I will be pleased to submit if you wish to include it in the record, though there is a good deal of other matter in it.

The CHAIRMAN. I do not think it necessary to put it in the record. That only applies to small plats.

Mr. LANDIS. I think his publication as to the effect of that mixture gives valuable information.

The CHAIRMAN. There are a great many things with reference to top dressing we do not care to 'put into the record. I could give you some information on that matter myself, but it is unnecessary to go into that.

Mr. LANDIS. Very well, but he calls attention to the difficulty of using this mixture from poisoning and caking and inflammability. Of course when mixed with cottonseed meal you practically have an explosive.

Col. BURNS. I would like to interject a statement right there, and that is that the Ordnance Department sold quite large quantities of surplus nitrate of ammonia after the war was over. We have sold over 5,000 tons of that nitrate of ammonia, one sale to fertilizer companies, and the fertilizer companies put the material into mixed fertilizers and sold it to the farmers. and so far as we are able to learn no adverse criticism of any nature has been put forth against the use of that nitrate of ammonia. I am just citing that to you as an actual example of what has taken place in spite of the things which Dr. Landis has said about it and in the most of which I thoroughly agree.

The CHAIRMAN. That would apply to this?

Col. BURNS. No, sir. That is nitrate of lime. I am talking about nitrate of ammonia, which is one of the materials we would propose to make at Muscle Shoals.

The CHAIRMAN. And that could be made with the arc process?

Col. BURNS. Yes, sir.

Mr. LANDIS. I have had that matter up with fertilizer mixers, that Col. Burns has spoken about, and must say that the reports I have of the behavior of the material from some of the fertilizer mixers who bought material were not as favorable as he says, but we must wait until the end of the season to learn the final result.

Col. BURNS. We have not received that criticism. We have sought it, but not found it.

Mr. LANDIS. We are waiting until the end of the fertilizer season before getting these final reports.

Col. BURNS. I have tried to find out if it was satisfactory, and we are informed it was. I personally went to one of the fertilizer companies myself about it

Mr. **Landis**. So much for the second product that it was proposed to manufacture at Muscle Shoals, nitrate of ammonia.

The **Chairman**. I do not want to hurry you, Dr. Landis, but what you have been talking about is just practical experiments which any farmer or any layman could make if he wanted to do it. I think what we particularly want here is to hear you on the scientific question and on the commercial values, and so forth, along the lines that Dr. Scott testified yesterday. We will be glad to have that information.

Senator **Kendrick**. Yes; the relative merits of the two processes.

Mr. **Landis**. I think that the commercial end that you are asking about is exactly the point I have been touching upon. If you had the material there is no way you could market it, which is the most fundamental of your commercial problems.

The **Chairman**. Of course, even being a layman, I can see where we may differ on that. I might sit here and talk all day about treating flax with formaldehyde, which I possibly know more about than any of you people who have not used any of it. I know it can be done, and I do it without caking, while scientific men will tell you that it can not be done. But there is no use of wasting any time on that.

Mr. **Landis**. I merely desire to present to the committee facts that have been gathered from 10 years of experience in the commercial world.

The **Chairman**. I know; but it would not take a man 10 years to test out whether these things can be used and put into use; trials of things of that kind. That is only a common, everyday thing that a man can know about if he tries it out; and if he tries it he knows whether it can be done or not.

Mr. **Landis**. The next matter I had to take up was the question of the third product mentioned, sodium nitrite. That material is made in two plants in this country, and I have already discussed it.

The next item which I believe interests you is that of the cost of making these products. That is also another commercial matter, as to whether these materials can be made at a reasonable cost. We just considered that it took 10 horsepower years of power to make a ton of nitrogen which goes into that product. The Ordnance Department figures that the cost of producing that power at Muscle Shoals is three-quarters of a mill per kilowatt hour, or in a better figure and just the same thing expressed in another way, $5 per horsepower year, not including interest. We can therefore consider that our 10 horsepower which is going into this product will cost us $50. We are told that by the Ordnance Department, and while I do not agree with it for the present I accept that figure. They tell us that to generate that horsepower they must expend $250 on the dam and power plant—$25,000,000 for the 100,000 horsepower.

Interest rates to-day are 5 per cent, and 5 per cent on $250 is $12.50 per horsepower year that somebody must pay; or on 10 horsepower, which we are figuring on, is $125. In other words, to fix one ton of nitrogen in that material there is required $175 worth of power to be paid for by someone or in some way or other. It requires labor to make that material. A rather interesting feature of this situation is that, ton for ton, nitrogen made by the arc process or made by the Muscle Shoals process, the cost of labor is not very widely different. I have Dr. Eyde's figures on the labor, and for producing 45,000 tons of nitrogen—the present capacity of the Muscle Shoals plant—according to his figures he would need about 3,000 men. During the war, however, when labor became scarce in Norway, they did a little better than that, and the latest figures that I have—last summer—were that it would take about 2,200 men in an arc-process plant of the same capacity as the Muscle Shoals plant, which is essentially somewhere around the number of men we are using. So, essentially, the labor cost would be the same. The process cost, and so on, is somewhat different but not very widely different. But if you were to take that figure which I have just given you, of $175 for power, and take all the labor, the same as the Muscle Shoals plant, and add to that cost of labor and power the cost of limestone and the wear and tear on equipment, machinery, and so on, this material could not be made at the same price that you could put out fixed nitrogen in other forms at Muscle Shoals.

The CHAIRMAN. If I may ask you: What does it cost to manufacture a ton of this nitrate of lime containing 13½ per cent of nitrogen?

Mr. LANDIS. I have not those figures available here, but I beg leave to submit those along with some other figures of cost which Mr. Washburn has promised to send you with his statement.

Senator KENDRICK. Did not you have something of an estimate a moment ago in your mind, when you were discussing this matter?

Mr. LANDIS. I had an estimate of about $250 per ton of nitrogen.

The CHAIRMAN. Nitrogen?

Mr. LANDIS. That is, per ton of nitrogen. I would have to translate that down to get a ton of product. But we can not speak of the cost of a ton of nitrate of lime or the cost of a ton of nitrate of ammonia and compare them in price per pound or per ton. This nitrate of lime has only 13 per cent of nitrogen content, and the nitrate of ammonia has 35 per cent nitrogen content. So I prefer to get the figures in content of nitrogen.

The CHAIRMAN. I will change my question: What does it cost to manufacture a ton of nitrogen with the arc process in the form of this sample of nitrate of lime?

Mr. LANDIS. I am giving you as a rough approximation $250.

The CHAIRMAN. And what would it cost to manufacture by the cyanamid process per ton of nitrogen?

Mr. LANDIS. According to the Ordnance Department figures, which we do not agree with but which are in your record here, it would be about $230.

The CHAIRMAN. So there would be a saving of about $20 a ton?

Mr. LANDIS. In the case of nitrate of ammonia. But I will send you the correct figures on that.

Mr. SCOTT. May I interpolate a remark?

The CHAIRMAN. Yes.

Mr. SCOTT. When the Norwegian people were fighting for a market in England they were always quoting, per unit of nitrogen, a lower price for nitrate of lime than anybody else could touch. They got below Chilean nitrate and everybody else, including cyanamid. My recollection is that they were selling a ton of nitrate of lime at one time at about $35. It had to come across the sea, and yet they were making a very good profit all the time.

Mr. LANDIS. The units he is speaking of are per ton of product, and not per ton of nitrogen. You will have to multiply his figures by about seven to make them comparable with those I gave.

In regard to these costs this English report was cited as authoritative. And it was reported that their costs in here were representative of the best knowledge that England had of peace times. Mr. Scott made a comparison of the cost of making nitric acid by his arc process and the cost of making nitric acid by what is known as the old commercial process, and the English report it is true says that the cost of one is about one-half that of the other. That is an unfortunate method of making a statement which the English report does not desire to convey. English conditions are very different from ours; under prewar conditions in England their labor costs were half those of ours but their raw materials were very much the same price. If you take a process which uses large quantities of materials and a small quantity of labor and compare the costs with a process which uses a large amount of labor and a small quantity of material, in England and America, you get two decidely different answers. And that is the situation which arises with respect to the old commercial process. They have a comparison of the cost of the product, and in that product you must consider the labor used, and in the arc process it is a much higher percentage and the result is that if you bring those two processes over here, with our high cost of labor, the one that uses the largest amount of labor is at a disadvantage with the one that uses the smaller amount of labor.

The CHAIRMAN. It requires more labor for the arc process than for the cyanamid process?

Mr. LANDIS. About the same. The figures show more than the Government's estimate for the most of the work at Muscle Shoals but I am willing to accept that roughly just the same.

Mr. SCOTT. I will guarantee to run the arc process with women, sir. They could not do that in the case of the cyanamid process.

Mr. LANDIS. I do not like to refute those statements, but if the committee is interested I have Dr. Eyde's report on labor costs, if there is any question about that. But I do not think it enters into the discussion here.

The CHAIRMAN. I do not think it necessary to have that report either.

Mr. LANDIS. All right. That brings out some rather interesting qualifications, of course, which must be placed upon the interpretation of a report like this, which are distinctively handling prewar conditions.

The CHAIRMAN. You have told us about the manufacture of nitrogen with the two proceses. Now, let us take nitric acid: What will it cost to make a pound, or to make 100 pounds, or take any unit you wish just in order to make a comparison, and tell us what it will cost to manufacture that unit of nitric acid by the arc process and what it will cost by the cyanamid process.

Mr. LANDIS. You have been given figures here by the Ordnance Department as to the cost of manufacturing nitric acid.

The CHAIRMAN. I know as to the Ordnance Department, but I would like to have them from you.

Mr. LANDIS. Mr. Washburn is going to send you a statement in detail of these costs. But as the question of preparing that statement will come to me, as I make those estimates, I will give these figures to you also. I have not the figures here now.

The CHAIRMAN. You can tell us what it would cost, say, to manufacture a unit of nitric acid with the one process or the other.

Mr. LANDIS. At Muscle Shoals?

The CHAIRMAN. I do not care where it is.

Mr. LANDIS. It makes a very decided difference where it is.

The CHAIRMAN. Then take Muscle Shoals, and we will take the manufacture of it in European countries also later on. But we will take one at a time.

Mr. LANDIS. The figures given by the Ordnance Department, which we are going to correct, is $231 per ton of nitrogen for the manufacture of nitric acid at Muscle Shoals. But we are going to send you a correct figure on that, which will be somewhat higher, we know, as well as the figure here.

The CHAIRMAN. That is, the cyanamid process?

Mr. LANDIS. Yes, sir.

The CHAIRMAN. Of course, you have not tried, or probably it would not be fair to ask you what you could do it for under the cyanamid process?

Senator KENDRICK. Do you happen to recall what the estimate of cost is on that product that has bene made by the Government?

Mr. LANDIS. That is, nitric acid you are speaking of?

Senator KENDRICK. Yes.

Mr. LANDIS. I just gave you the figures that had been made for the Government, $231.

Senator KENDRICK. I supposed that was your estimate or Mr. Washburn's.

Mr. LANDIS. No; Mr. Washburn is going to send you those figures in detail. This Government estimate is $231; ours is a little higher than that, not quite as low. That estimate is to be found on page 97 of your printed record.

Estimate of cost of nitric acid at Muscle Shoals as projected on basis of ammonia cost per ton nitric acid (100%), actually as 50 per cent.

[Presented by Frank S. Washburn, Apr. 10, 1920.]

Item.	Quantity.	Unit cost.	Total.
Ammonia gas	0.307 tons	$196.35	$60.30
Steam power	240 K. W. H.	.0039	.94
Reworking platinum			1.50
Supplies			.70
Repair and renewal materials			1.25
Labor:			
Manufacturing			1.70
Mechanical			.25
Total			66.64
Plant general expense			.80
Replacements			4.00
Cost per ton nitric acid (100%) in form of actual 50 per cent acid, exclusive of interest on money already expended, executive office expense, selling expense, concentration, packing, and taxes			71.44

Now, gentlemen of the committee, using steam power which we are giving consideration to at the minute because the dam is not ready, the cost of making 1 ton of nitric acid is given as $50.88. There is 29 per cent of nitrogen in nitric acid, so they divide that by 22, which gives $231 per ton of nitrogen, the unit we are speaking of. In the arc process it will be somewhat higher than that. I will furnish those figures if you desire although I would rather they should come from a man who is in the arc industry.

Estimated cost of producing nitric acid at Muscle Shoals by the arc process per ton of nitric acid (100%) actually as 35 per cent.

Item.	Quantity.	Unit cost.	Total.
Steam power	2.3 H.P.years	25.62	$59.00
Supplies			3.00
Repair and renewal material			5.00
Labor:			
Manufacturing			15.00
Maintenance			
Total			82.00
Plant general expense			3.00
Replacements			[illegible].00
Total cost per ton of arc process nitric acid (100%) actually as 35 per cent, excluding interest, on acid plant, executive, office expense, sales expense, packing, taxes, royalty.			90.00
To concentrate this acid to-day to 96 per cent strength, including losses, and exclusive of interest on plant, executive office expense, sales expense, packing, taxes, concentration, royalty, would cost per ton in addition to first cost of acid.			20.00

The CHAIRMAN. Well, I think the committee is interested in having your figures and your estimates on the arc process just as well as we are interested in having figures from Dr. Scott on the cyanamid process. As Senator Kendrick said the other day, the committee will make its own deductions and allowances, of course.

Mr. LANDIS. I will include with Mr. Washburn's figures those as to the arc process.

There is another interesting feature: Mr. Scott was comparing from this report the cost of nitric acid made by the chemical and by the arc process. Unfortunately he did not continue in his reading of this report, in which it is very plainly brought out in a very complete statement of facts that while the costs of nitric acid by the two processes were comparable with favor to the arc process, yet he did not continue to read what is said in the report.

The CHAIRMAN. Will you continue to read that report?

Mr. LANDIS. This is the final report of the Nitrogen Products Committee, in England. Under the heading "Production costs of synthetic nitrates," paragraph 203, it is stated:

> When an allowance is made for interest upon the capital cost of the chemical plant, for the cost of marketing and for profit, these, of course, show little or no margin as compared with the prewar market price of combined nitrogen in the form of Chilean nitrates.

In other words, Mr. Scott was speaking of the comparison of nitric acid, which, by the way, under English conditions was in favor of the arc process. But nitric acid is not a fertilizer. It would kill a plant even if you brought a bottle of it near a plant. You must convert it into these materials, and Dr. Scott did not read the part which goes ahead to speak on the making of fertilizers. In other words, he did not read the paragraph headed, "Production costs of synthetic nitrates," the finished product. The arc process, as Mr. Washburn explained, has for its primary product nitric acid, and it costs you money to continue that on to any other product, just the same as the cyanamid process has for its first product cyanamid. The final marketing form is really the comparison which you should make and not the intermediate product of no value in agriculture. So much for that situation.

There are one or two other bits of information that I think the committee should have, some of which I do not quite agree with. There was mentioned that we were so dependent on a special shipment of Russian platinum for the Muscle Shoals plant. I think we all know that there was a large quantity of platinum brought over during the war from Russia for munitions purposes, but as a matter of fact the platinum that went into the Muscle Shoals plant was in the assay office in New York before the particular lot of Russian platinum arrived. I was down there myself and tested the bars. Where the Russian platinum did finally go was into the sulphuric acid plants. Had we continued to build a great number of nitrate plants such as Muscle Shoals we might have had to obtain such platinum later but we did not have to do it for the Muscle Shoals plant.

The CHAIRMAN. As a matter of fact you did not manufacture anything.

Mr. LANDIS. The platinum was there.

The CHAIRMAN. But it is evident that you did not have use for it.

Mr. LANDIS. The plant was all complete even up to the platinum; or, rather, the platinum was all made but we did not ship all of it to Muscle Shoals.

The CHAIRMAN. Isn't it a fact that you require platinum?

Mr. LANDIS. Yes, sir; but a very much smaller quantity in comparison with our output than in the case of plants like Old Hickory and Nitro, W. Va., and the du Pont plants at Hopewell, where they use platinum for other purposes and in large quantities.

The question has been brought up that it is necessary to operate this plant as a preparedness measure. The principal point made was that you should have a force at work all the time in order to continue operation of these plants. I want to say to you gentlemen of the committee that the Muscle Shoals plant, a unit in every part of it, was operated to show that it worked, and it did produce a small amount of material, some 2,000 tons of this nitrate of ammonia. The constructors of that plant walked out of the doors at one end of the buildings and the operators walked in at the other, and a test was carried on for two weeks which showed 100 per cent designed efficiency all the way through. In other words, it is not a proposition that you must keep these plants running in order to have operators. We found operators for that large plant down there and made a test run, you might say, starting it the day that the constructors left the plant. I disagree with that proposition.

The CHAIRMAN. What do you say about the question which has been discussed before the committee as to the compound manufactured with the process you have at Muscle Shoals—that it is only a bursting compound and is not a propellant compound; what have you to say in reference to that.

Mr. LANDIS. I agree with the statement made by Col. Burns in that respect, that the ultimate product which was to be made at Muscle Shoals was essentially this material [pointing to sample in bottle on table], nitrate of ammonia. But physically it was not in that form quite. The specifications originally called for that, but later it was made in small granules. That material forms a part of the bursting charge for a shell, a high explosive shell. Ammonium nitreate is not particularly an explosive itself; only under the most extraordinary conditions could you explode that bottle of ammonium nitrate as it sets there on the table. In other words, I have no fear of carrying that material around with me, or keeping limited quantities of it in my office, because the conditions under which it would explode are most unusual. To be used as a military explosive it must be mixed with other materials in order to make that material detonate, as it is called, and usually the material that that is mixed with is either nitroglycerin compounds, like dynamite, or for a shell charge T. N. T. T. N. T. is an explosive that is easily ignited or detonated. That material as such is almost as inert or nonexplosive from an explosive standpoint as calcium nitrate, for instance; possibly not quite so much so, but ordinarily speaking that is so. It can be converted into nitric acid by the old process which we have been using for years in treating sodium nitrate very largely with sulphuric acid. That has been done in Germany. I have seen it done during the war. I was in Germany during the war up to the time when I was forced to leave; and it can be done in this country if we are forced to do it.

The CHAIRMAN. Would it be practical and economical to do it?

Mr. LANDIS. It would give you half of its nitrogen content in the form of ammonium sulphate, but it would require considerable handling to make it valuable for the market. However, in time of war anything is practical that produces results; I will say that.

The CHAIRMAN. But this is time of peace. Is it practical and economical to go on and manufacture these things now; that is really the question before us.

Mr. LANDIS. The Government sold ammonium nitrate at 4 and a fraction cents a pound to some fertilizer mixers, I believe, although probably Col. Burns possibly knows more about those figures than I do.

Col. BURNS. They had a varying scale. When they first started the price was quoted low, about 3½ cents a pound, and then the price gradually rose until the last sales I believe were in excess of 6 cents a pound or $120 a ton.

Mr. LANDIS. That scale, as well as I understand it, was something of this nature: The fertilizer man obtained a very much reduced rate as compared with that for other manufactures.

Col. BURNS. That is because they bought first.

Mr. LANDIS. All right. Muscle Shoals plant will produce ammonium nitrate I believe at a cost probably lower than 7 cents a pound, but that is such a high price as fertilizer materials are sold that we do not consider it profitable. It would have to be sold at a materially less price in order to be attractive as a fertilizer. But those figures will be supplied you as to just what it will cost to operate there, and in detail.

Mr. SCOTT. May I say a word?

The CHAIRMAN. Yes.

Mr. SCOTT. Mr. Landis said about Muscle Shoals, as to its not being necessary to run it in order to have personnel or men accustomed to the work. I want to say that when they were getting ready to run that plant down there the cyanamid company rounded up all the experts they could find in the country and put them over in their plant at Niagara Falls, and elsewhere to learn how to operate, etc. Some came to me complaining of the treatment they received from the cyanamid people. Among other things I was told that it was very difficult in one of the processes at Niagara Falls to get any men to work at all; that they had to get ignorant negroes from the South who did not understand the job they were coming to, and that even the negroes found it out after a while and left. That situation produces a condition of poisoning which incidentally prevents them from drinking. It would endanger their lives if they should drink alcohol. That has been made fun of by Dr. Landis, but it is a condition that probably a white man would not want to get himself into. That is one of the problems of working the cyanamid process.

Mr. LANDIS. Mr. Chairman, the ethics of my profession in this country would not permit me to obtain information in the manner which has just been represented to you by Dr. Scott. That is, to send spotters into another man's plant——

Mr. SCOTT (interposing). Not at all. They came to me about the treatment received from the Washburn crowd.

Mr. LANDIS. In order to characterize the quality of the information the gentleman has sought to give to this committee, I will say that I worked at Niagara Falls for four years. I get to Niagara Falls practically once a month now, and in all my knowledge of that plant up there, covering a period of eight years' experience, there have been just two colored men—that is, to my knowledge—working at that factory, and one of them is a cook and the other is a table waiter in the office lunch room.

Mr. SCOTT. I will give you the name of the gentleman who gave me this information. [Writing something on a piece of paper.]

Mr. LANDIS. The ethics of our profession do not countenance such things in this country. That may be countenanced in the old country but certainly is not countenanced in our profession here.

Mr. SCOTT. He is an Englishman. [Handing the piece of paper on which he had written the name to the chairman of the committee.]

Mr. LANDIS. Oh, well, that may explain it.

Senator MCNARY. I do not think we should go into those things. If gentlemen who are here and who are expected to give information to this committee intend to indulge in personalities, we might as well adjourn the hearings.

Mr. LANDIS. Another item brought up was the unsympathetic nature of the so-called nitrogen trust, or nitrate organization, in this country; that is, in not permitting a man to come in with a new process he had developed, and so on. I do not think that is true. I know that the Du Pont companies that are interested in fixation of nitrogen in this country maintain an office which is devoted exclusively to hearing men who come in with new processes. It is in charge of a very important member of the Du Pont organization. And I know that we have always maintained such an office—in fact, I have been in charge of that office—to listen to men who came in with processes. I hate to have it a matter of record that we in the United States are so inert that the men in our commercial organizations will not receive or hear an outsider bringing in anything that might interfere with our welfare, and so on, because it is not true. I consider that we in the United States possess the finest class of engineers and technical men in the world, and I would not take my hat off to any German scientist or any German manufacturer when it comes to the matter of chemical manufacture or development in any way. I spent five years in that country and know how they do it. And I want to say to you, gentlemen of the committee, that our office has always been open and that we have given consideration to a great many processes; I think at least two or three a week, on the average, come in there, and they are studied out in great detail, and we are doing all we can to help the industry.

And that is because, as you must realize, that we have an investment as Mr. Washburn said of $10,000,000 in plants. We have power contracts with years to run. If there is going to be some new process come along which is going to produce nitrogen cheaper than ourselves we are automatically going out of business and lose all our investments. So if we can get hold of that new process and put it to work we will naturally be able to save something out of our present investment even if it is only the power contract or the buildings or personnel or something in that way. That is true of every industry of this kind. There is no closed door to anybody, and the man in the industry is the man most interested to find the cheapest way to develop the product he is manufacturing and has a market for.

I have a great many other matters which I might criticise which have been presented. But I do not believe the information would get us along very far, as they are matters of detail more or less, and I doubt if it is worth my time or that of the committee to take them up. However, if at any time there is any question that may come up I certainly hold myself open to present to you any information that I have and at any time, or to give you any help that I can in any way or anywhere in regard to this industry.

Senator KENDRICK. Before you leave I want to ask you some questions: What is the principal objection of your company to the Government going on and operating this Muscle Shoals plant?

Mr. LANDIS. I think Mr. Washburn very strikingly characterized that situation when he said he had no objection to the Government as a legitimate competitor but that he did object to the method in which it was proposed to do it at Muscle Shoals, and his only information on that is gained from the hearings here. In other words, private industry can not meet the Government as a competitor if the Government does not charge interest on its money invested and has no taxes to pay. We can not meet that competition. And it is distinctly stated in the bill here that this corporation shall not be liable for taxes, and there is no interest figured in the charges.

Secondly, we can not compete when they propose to take our customers away from us as is mentioned and which Mr. Washburn brought out quite strikingly in his remarks and which it is unnecessary to repeat here. Thirdly, was the question of condemnation of processes, patents, which patents were not included in the original contract. Mr. Washburn rests his case upon the justice of the claims and the statements in the original contract, and I believe he distinctly stated that he did not fear, if they were carried out and the Government did not attempt to compete with him without these fixed charges, he Government competition.

Senator KENDRICK. Assuming, as we have the right to assume, that the Government would not infringe upon any rights of individuals or corporations without satisfactory adjustment with those different interests, would it not be entirely consistent under the circumstances for the Government to go ahead and operate this plant for the primary purpose of having it for use in time of emergency?

Mr. LANDIS. That involves the question whether this plant is going to cost the Government more money than the results you will obtain by having it ready to operate.

Senator KENDRICK. Yes; and would it not, according to Mr. Washburn's own statement of Government inefficiency in everything it attempts to do, his idea being that the Government could not possibly operate anything, as I understood him, in a satisfactory way; would it not be possible for private and corporate business interests to compete even with the Government under those conditions?

Mr. LANDIS. The Government has behind it the United States Treasury. Private interests can not compete and hold markets with the Government with capital behind it of that nature.

Senator KENDRICK. You understand that the Treasury is not exactly standing wide open even though Congress is inclined to be generous.

Mr. LANDIS. Well, I hope not.

The CHAIRMAN. Not unless you are going to build battleships or something of that sort.

Senator KENDRICK. Which certainly has nothing to do with agriculture.

The CHAIRMAN. No. Mr. Landis, did you hear the statement made by Dr. Scott yesterday with reference to what caused the Boer war?

Mr. LANDIS. Yes, sir; I heard that statement.

The CHAIRMAN. Do you care to make any comment on it?

Mr. LANDIS. I do not care to make any comment on that other than that I do not agree with his conclusions. It is a political matter which I do not think we Americans should discuss because it affects two foreign countries.

The CHAIRMAN. When you say you do not agree with his statement you mean that that is your conclusion? You have no particular proof that it is not so, have you?

Mr. LANDIS. My conclusion is that the munition manufacturers did not cause the Boer war.

Mr. SCOTT. I used the the word "precipitated" it, and I stick to that.

The CHAIRMAN. If we could avoid war by turning the manufacture of explosives over to the Government perhaps it would pay the Government to pay the individual manufacturers whatever profit they would want and still it would be cheaper to give them a bonus and let the Government do the manufacturing.

Mr. LANDIS. Of course, your understand, Mr. Chairman, that this question of making munitions is not that of simply operating the Muscle Shoals fertilizer plant. That applies to a very small part of a plant necessary in the manufacture of explosives. We have these great explosive companies that make innumerable varieties of explosives that would be of little or no value for warfare; that is, commercial explosives, coal-mining explosives, and things like that.

The CHAIRMAN. Yes; I know. Would it be necessary to further improve that plant in order to make it what it ought to be even as a matter of defense? Ought we not to further improve the plant so that we could manufacture at least a large quantity of what would be necessary in the carrying on of another war in case we should happen to have another war?

Mr. LANDIS. Do you mean by the word "improve" to enlarge or to change?

The CHAIRMAN. No; I mean to enlarge. I am not speaking of any process whatever. But it is stated now that the plant is in order so that we could manufacture a certain quantity of compounds necessary in the use of explosives in order to carry on war. Should we let the plant rest just where it is or should we utilize the water power? As it is now we are not utilizing the water power at the present time. The question is, Should we build a dam and should we enlarge the plant or should we leave it just as it is?

Mr. LANDIS. Speaking from the standpoint of an engineer who must always look to the cost of producing a material which must find a market, and that cost is always divided up into four items—divided up into cost of your raw materials; divided up into cost of your processing, labor, repairs, etc.; divided up into your distribution—that is, your final preparation of bagging and selling, executive offices, etc.; and, finally, the fixed charges, such things as interest. We commercial men can never dissociate one of these four from the other. Now, from the engineer's standpoint, to complete that dam I agree in every respect with Mr. Washburn, although we are at odds in the matter of a great many other things, that commercially it would be wrong to saddle the cost of power for peace times upon that community down there based upon present high prices of cement and concrete and labor and electrical machinery, etc. In other words, to go into that operation now, unless we are going to make the thing a gift to the community—not self-supporting, but an outright gift—will put a cost for power upon the community or upon the United States as a whole far beyond what that cost justifies. And I would say as an out-and-out plain engineering proposition we should not go ahead at these high costs.

Senator KENDRICK. That seems a very natural conclusion, and yet we see all around us the best business interests of the country going forward with their plans and developments. They are undoubtedly proceeding on the theory that we are not going back to the old level of prices and values very suddenly; that there is to be a long period of time before, if ever, we return to those standards of value. I think perhaps that is true. You take the question of farm labor, and it is twice as high to-day as, we will say, two years before the war, and those who consume farm products might as well know once and for all that there is not going to come a time again when the people of the farms and the ranges will do endless and endless rounds of drudgery under the same old conditions and without sufficient compensation. That is going to have something to do as I take it with the fixation of prices and values on all kinds of products. There has not been a time, according to my judgment, in 30 years when there has been even a fair valuation of farm products, of the foodstuffs on which the people were dependent, for a minute. Do you believe there has been, Mr. Chairman?

The CHAIRMAN. No; I do not believe it, just as you say, and that change will necessarily have to come or the people will have to go hungry.

Senator KENDRICK. Education has, I believe, shown the man on the farm the extreme disadvantage at which he was laboring, and he declines to go further along that line and in that direction. I think we are on a higher plane of values and to remain there. So if that be true it might actually throw a different light on this situation as to the cost of present or early development at Muscle Shoals. If present prices of labor and of materials are not to decline, we might as well go ahead if we want to use that plant. That is what all other lines of industry are doing.

Mr. LANDIS. I do not think that the prices of labor and the prices of materials within the very near future will drop as low as the prewar levels, but I am quite certain they are going to drop materially below present prices, though not to the extent of 1913 and 1914 prices. On the other hand you have in the cost estimates submitted by the Government here some interesting facts bearing on that. For instance, I turn to page 95 of your hearings and find that the cost of coke in Alabama is put in here at $6 a ton. I want to say to you that coke has not sold in Alabama at $6 a ton for a very long time. I obtained quotations just before I came down here on Alabama coke, prior to April 1, and the quality of coke demanded by that plant down there was quoted at $10.75 a ton on very large tonnage from responsible people.

It is true that these estimates, as stated, were made in the summer of 1919, but the Government's price of coke as existing then was $8 and more per ton. We used a special grade of coke and had to pay a little more than the blast furnaces do for their coke. I notice in here just such items as that. In other words, throughout these costs they have not taken the prices which you say are going to stay up and which I agree with you, for some time at least; they have not taken present day prices but have uniformly taken prices of materials below the present market. The result is that if you will put present day prices on these items for things we are buying every day, you will find a different result. I had occasion to buy a large quantity of electrodes for a plant, and I see 5 cents a pound stated here, while I paid 8½ cents at Niagara Falls, being the cheapest price I could get last month.

So, as I say, the result is that we disagree entirely as to the matter of these costs because they have estimated very much lower than the prices we can buy things at to-day. And I suppose they have taken these unit prices upon the assumption that at some future time prices will drop to that level. So it is not a fair conclusion to take these costs and upon them base the fact that your plant is going to make money. You can not buy raw materials at the prices quoted here, and you can not make the products at this price.

Col. Burns. It is true that the prices of raw materials are higher than the prices we have set down in this estimate of cost. On the other hand, it is also true that the selling price of the finished product we refer to is materially higher than the selling price which we have in here. So that the two balance each other. We have sulphate of ammonia in here for instance at $65 a ton. They have testified that the new long-time contracts are made at $90 a ton, which is $25 over what we have as the price here, or, roughly speaking, 40 per cent advance. The spot price for sulphate of ammonia to-day is $150 or $160 a ton, or two and a half times our estimate.

Mr. Landis. Those are among the figures that Mr. Washburn is going to present to you, a comparison of costs if you want it of the market to-day if you were to have to buy these materials. We have the quotations as we are buying these materials every day and know what they are going to cost, by comparison with present market prices of these materials, which is the only true comparison that should be made.

Senator Kendrick. Col. Burns, may I ask what percentage your prices named here are under the actual market prices of these different products at this time?

Col. Burns. They vary.

Senator Kendrick. How much lower are these figures?

Col. Burns. We will have to work that out for you.

Senator Kendrick. It is not important. I just wanted a general idea of the situation.

Col. Burns. Take the labor items, which are quite a big portion of the whole thing, and I think we are basing common labor at $2.80 a day, while common labor to-day in the Muscle Shoals district is getting $3 a day. So you will see we are 20 cents a day under the price being paid for common labor. That is probably our most favorable item. Coke is our most unfavorable item, I think. I would not be surprised but what, on the whole, it would work out that we are perhaps 25 per cent lower than the present market prices. But that is a mere estimate on my part.

Senator Kendrick. We are just at the present time on a war basis. There has been no decline to speak of, and I would think it quite believable that you could employ ordinary labor at $2.80 a day in the construction work there in that particular section of the country. I should say you could do it there if you could do it at any place in the United States.

Col. Burns. At the Muscle Shoals Dam to-day, unless I am misinformed, labor averages $3 a day—common labor.

The Chairman. Dr. Landis, have you anything further you wish to say?

Mr. Landis. I have nothing further. I thank you, gentlemen of the committee.

The Chairman. We are very much obliged to you, Dr. Landis.

Have you anything further you wish to ask, Senator Kendrick?

Senator Kendrick. Nothing further.

The CHAIRMAN. When will the War Department be ready to be heard?

Col. BURNS. About Monday or Tuesday, if agreeable to you. We want to be sure that the data which we give you is correct, and some of these points raised are quite complicated, and, of course, we have not had time to prepare our statements, as we have been up here listening to the evidence.

The CHAIRMAN. Then, when the committee adjourns we will adjourn to meet Tuesday at 10.30 o'clock a. m.

Mr. SCOTT. May I make a few remarks before the committee adjourns? It will not take very long.

The CHAIRMAN. Yes; the committee will be glad to hear you further for a few minutes.

STATEMENT OF MR. ERNEST KILBURN SCOTT—Resumed.

Mr. SCOTT. I have asked to say a word or two more because of the question that was put to me yesterday, as to what would be the cost of an arc plant. In Mr. Arthur Glasgow's letter, to be found on page 90 of your hearings, he says:

> Our present expectation is to utilize the capacity of eight carbide furnaces approximately as follows:
>
> Four furnaces (or 40 per cent of plant capacity) for the manufacture of 86,000 tons of ammonium sulphate.
>
> One furnace (or 10 per cent of plant capacity) for the manufacture of 22,225 tons of dry cyanamid—making 24,445 tons of hydrated and oiled cyanamid.
>
> Two furnaces (or 20 per cent of plant capacity) for the manufacture of 22,000 tons of ammonium nitrate.
>
> One furnace (or 10 per cent of plant capacity) for the manufacture of cyanamid, ammonium sulphate, ammonium nitrate, or intermediate product, according to demand.
>
> When the hydroelectric power is completed the remaining two furnaces will be applied to the manufacture of the then most advantageous product, possibly ammonium phosphate.
>
> Meanwhile every effort will be made to cultivate the use, firstly of cyanamid, and secondly of ammonium nitrate, in preference to ammonium sulphate, because the cost per unit of nitrogen is much less in those forms than in the form of ammonium sulphate.

Now, on page 93, there is an amount in the estimates of $900,000 for sulphate of ammonia plants, buildings, and equipment; also $300,000 for acid storage. I believe that sulphate of ammonia made from coke-oven plants and gas plants will control the market, because when made from those plants it is a by-product and a by-product, of course, can be sold at a price to undercut any sulphate made at Muscle Shoals. Now, my advice is, keep out of sulphate of ammonia business and do not run those four furnaces for that purpose, but keep them closed down and use the money, $900,000, plus $300,000, also the extra money that would be available by not running them, for an arc plant.

One of the most expensive parts of the Muscle Shoals plant is the absorption towers, which require a building about 1,000 feet long and 90 feet high. Under Mr. A. Glasgow's proposal a very great deal of that expenditure is going to lie idle anyway. They are not going to use the towers except for making a very small amount of nitric acid to join with ammonia. Those towers are the very thing for the arc process, so I am proposing to you a method whereby Muscle Shoals can be utilized more fully; not only so that it will utilize the by-products of the cyanamid plant.

Those towers are wanted to make nitric acid and they are by far the biggest expense in an arc process plant. You have already got them there, and to put in an arc process at Muscle Shoals is easy and profitable, because you have the largest part of the expenditure already made. You only have to put in electrical furnaces, switchgear, and some blowers, and cooling apparatus, and then, of course, the apparatus for making nitrate of lime. But, of course, you can make ammonium nitrate—and I believe as sure as I sit here that the fertilizer of the future is going to be nitrate of ammonia—Mr. Glasgow's report says:

> We can not sell you ammonium sulphate at less than the market rate, governed by the law of supply and demand; but if you are willing to take the trouble to use your nitrogen fertilizer in the form of cyanamid or ammonium nitrate, we can make you immediately the very great savings described above. We, for our part, undertake to remove the physiological disadvantages of cyanamid by hydrating and oiling, and to relieve the hygroscopicity of ammonium nitrate by coating; and we except to make further reductions in the prices of cyanamid and nitrate when cheap water power becomes available.

Col. BURNS. With reference to ammonium sulphate, it has been the policy of the Government in recommending this action to sell at the start the fertilizer which it is absolutely certain will be satisfactory to the farmer and not at the start nor until the facts are thoroughly developed try to sell something to the farmer that might not be satisfactory to him. Sulphate of ammonia is a tried and true fertilizer. It has been used for years and years and is thoroughly satisfactory, and that is the reason we have the bulk of our plant down there in the form of ammonium sulphate. We would like to sell ammonium nitrate as a fertilizer, which Mr. Scott mentioned, and just as soon as the trade would absorb that it would be the thing we would prefer to turn out.

Mr. SCOTT. Or nitrate of lime, I suppose?

Col. BURNS. Well, we have not gone into nitrate of lime and I would not say about that. I want to get your point clear.

Mr. SCOTT. With the money provided in the bill, $12,500,000, you can by simply changing the arrangement of the plant install an arc process plant which will be complementary to the cyanamid process. All chemical industries are made up of complementary plants for the purpose of being able to use the by-products of one plant as the main product of another plant. If you are going to draw a line at Muscle Shoals and not follow the standards of chemical practice you will make a mistake.

I would suggest that an arc process plant be installed on the lines on which you have data and drawings in very great detail, in the nitrate division offices, instead of installing all furnaces of the Norwegian type, which is probably what is arranged at present; that you put in some furnaces of the Norwegian type and other furnaces designed by any one who may come along and satisfy Col. Burns and others in charge that they are good. Then you will give everybody a chance, and you will have a personnel ready in case of war who can work all processes.

We experts can not always see the other fellow's point of view, and more especially when giving evidence before you gentlemen.

We have to make our case. Of course, I am trying to make my case, and Dr. Landis is trying to make his case. I know that Dr. Landis is an eminent scientific man. But he has got that financial group, and it is an international group in my opinion, behind him, and therefore his evidence is tinged by that fact. I have cut myself adrift, as far as I can, from that kind of thing, and I am speaking very frankly and very freely.

We must not allow people who make armaments and those who make explosives to guide us and goad us through newspaper articles and other means into war. It is to their interest to get us into war and keep us in war, for it is by that means that they make profits. In peace times they do not do so well. If the nations can agree they will not have any explosives made for war-like purposes, I do not see what more we would want in order to prevent war. Explosives and poison gases are the essence of modern war.

The CHAIRMAN. If the munition manufacturers are even a large factor in precipitating wars, it would pay us to give them a pension and retire them, wouldn't it?

Mr. SCOTT. To put them out of business in any way rather than have a war like we have just had. Civilization is in jeopardy if we allow that kind of thing to go on.

The CHAIRMAN. Did you hear the statement made by Mr. Landis this morning that approximately 9,000 tons could be manufactured from the water power at Muscle Shoals?

Mr. SCOTT. No; I was not in. Nine thousand tons of what?

The CHAIRMAN. Of nitrogen.

Mr. SCOTT. I have not been into those figures.

The CHAIRMAN. And that practically five times that much could be manufactured with the cyanamid process.

Mr. SCOTT. If you compare the two processes, you have to take in all of the energy that must be availed of—representing all the fuel to make steam, and the use of the railroads to transport the coal, lime, and fuel, the power used in the quarries, and the coal mines, and the coking of coal. The power used to make carbon electrodes, etc. But they do not do that. There is not a very great deal of difference in the total power between the one and the other.

Mr. Washburn complained that they might be put out of business by the Government. Gentlemen, that is all wrong. He did not believe it. They have made a good deal out of this job already. They have put that money nicely by. Cyanamid is a valuable chemical product. It is near to cyanide, and cyanide is the basis of the gold-mining industry. They are sending large quantities of cyanamid to California to make an insecticide. It is a very profitable industry. They are not going to be put out of business because the Government is going to run Muscle Shoals.

The CHAIRMAN. The committee is very much obliged to you, Dr. Scott. The committee will meet again next Tuesday, April 20, 1920, at 10.30 o'clock a. m.

PRODUCTION OF ATMOSPHERIC NITROGEN.

TUESDAY, APRIL 20, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

The committee met at 10.30 o'clock a. m., Senator Asle J. Gronna presiding.

Present: Senators Gronna (chairman), Smith of South Carolina, Ransdell, and Kendrick.

Present also: Hon. Newton D. Baker, Secretary of War.

The Chairman. The committee will come to order, and we will take up for consideration Senate bill 3390, a bill providing for the production of atmospheric nitrogen. Col. Burns, whom do you wish to have heard first?

Col. Burns. Mr. Chairman, one of the points raised by Mr. Washburn, and practically the chief point, was the negotiations that took place between the American Cyanamid Co. and the Ordnance Department; and if I have the correct impression, it was his statement that his first offer to the War Department was on a basis of practically no profit to the American Cyanamid Co., and that throughout his war work it was not his desire to make any unreasonable profit. Now, in order that you may get a proper picture of those negotiations, Col. Joyes is going to make a statement, as he was at all times intimately connected with the negotiations that took place.

The Chairman. You want Col. Joyes to be heard first then, Col. Burns?

Col. Burns. Yes, sir.

The Chairman. Very well.

STATEMENT OF COL. J. W. JOYES, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Col. Joyes. Mr. Chairman, I understand that what is wanted from me is rather particularly a statement of the nature of the contractual relations entered into between the United States and the Air Nitrates Corporation and the American Cyanamid Co., the considerations proposed, the relative advantages of both sides, etc.

Senator Smith of South Carolina. Colonel, do I understand that the Government entered into a cantract with the American Cyanamid Co. to use their processes, or to use the product of processes that they had in operation, or both?

Col. Joyes. Well, they had contracts for both purposes. The contract that I speak of, however, was entirely one for using the patent rights and the knowledge of the American Cyanamid Co. to erect a plant at Government expense for the use of the Government for the purposes of the Government, to make the products which the American Cyanamid Co. controlled. There were other contracts; so that to answer your question I must mention them, though I and the people associated with me have nothing whatever to do with them. Those were contracts directly for the manufactured products from the American Cyanamid Co. We purchased ammonia directly from them. That was handled, however, through a department of the Ordnance Department, which was buying such already manufactured articles.

Now, with regard to the nature of the propositions that were made to the United States for fixation plants, the history begins some years before the war. There were a number of projects that were put up. Some came before Congress. A lot of others were discussed without ever coming before Congress. But there was one that was actually put before Congress, which was in the nature of a so-called cooperative plan of operation between the United States and private interests, the private interests in question being, presumably but not necessarily, the American Cyanamid Co. Mr. Washburn, the president of the American Cyanamid Co., however, worked up the plan—with what assistance I do not know, but he presented it, at any rate, and did a good deal of explaining of the plan to committees of Congress.

I have here a letter of July 26, 1916, from Mr. Washburn, as the president, presumably, of the American Cyanamid Co.—the letter does not give his full title, but undoubtedly that was it—addressed to Gen. William Crozier, giving estimated costs, etc.

In brief, the plan presented was that the Government should spend in the neighborhood of $20,000,000 to develop water power and to put in some portion of a plant for making nitric acid for war needs; while if that were done and the American Cyanamid Co. got the power from the dam at 3 per cent of its cost to the Government per annum—which means, of course, at a cost per annum of 3 per cent of the cost of installation—then the private interests would build a plant for fertilizer production, expending, the estimate indicated, some $20,000,000 or $24,000,000; and would then make the fertilizer, at the same time making a small amount of nitric acid in that portion of the nitric-acid plant which the Government had paid for, for the purpose specifically of having the nucleus of an organization for going into the larger scale manufacture of nitric acid when war came on. But there was not to be completed under that capitalization, which was in the neighborhood of $40,000,000, a full plant for the manufacture of even the amount of nitric acid which was then estimated for the needs of war, and that estimate was really absurdly low. The estimate of war needs at that time is not really to be called an estimate; it was an assumption of an amount which we should envisage as one we would certainly need—180,000 tons per year. That was altogether too small, as the experience of this war showed. But then to develop that amount of manufacturing capacity for nitric acid which was what the Government wanted for war would require a still further investment on the part of the Government, which had already put in $20,000,000, presumably.

In this letter which I have referred to there are estimates given for future Government installations for the ultimate acid production, amounting to only about $3,300,000.

The CHAIRMAN. Col. Joyes, can you give the committee the date of that letter?

Col. JOYES. That is July 26, 1916. I have not gone into that in detail, to go right through the estimate with you, but it could be done.

Senator SMITH of South Carolina. The proposition, then, from Mr. Washburn, representing the American Cyanamid Co., was that they, the cyanamid people, were to put up about 50–50?

Col. JOYES. Of the capitalization; yes, sir; about that.

Senator SMITH of South Carolina. And then they were to sell both for agriculture and for munitions purposes at a certain price?

Col. JOYES. Well, at a market price.

Senator SMITH of South Carolina. Now, on the investment of that capital what per cent did they require—on just the investment of their capital? You mentioned there something about 3 per cent?

Col. JOYES. That was on the Government expenditures. It was proposed that the power developed by the Government structures should be given to the company at a cost which was 3 per cent of the capitalization, the argument being that that was the rate of interest which the United States was then paying, and it represented practically no expense to the United States. That was, I believe, essentially correct for that time, but it did not represent what the power could have been sold for by the United States if the United States had gone into business. Of course, there was a good deal of argument before committees about that, saying that there was no market sufficient to attract private capital, and a good deal of that sort of thing. But power as power was worth more than that at any place where it had a market at all.

That was the nature of the proposition at that time—the Government to put in the power plant, combined, of course, with the navigation project, the two to go together, although they were for separate purposes and represented separate items of cost. The Cyanamid Co., with power guaranteed to it at such a low rate, would feel that it could make an investment down there for the production of fertilizer, and that they would undertake in doing so to produce some of the particular products which the United States would need in time of war.

That was discussed, and there was nothing very definite done about it. It entirely failed of actual passage along the lines recommended; but more or less growing out of those discussions came the passage of the $20,000,000 appropriation for nitrate supply in the national defense act of June 3, 1916.

The CHAIRMAN. Was the proposed arrangement satisfactory to the Cyanamid Co.—the one you have discussed?

Col. JOYES. It was put out over the signature of their president, sir, and he argued in favor of it on a number of occasions.

Senator SMITH of South Carolina. You say nothing came of that discussion?

Col. JOYES. Nothing came of it; no, sir.

Senator SMITH of South Carolina. Now, have you any contracts existing between the American Cyanamid Co. and the Government?

Col. JOYES. Yes; I was coming to that. I wanted to give a little of the earlier history of the affair, to show you how it came up and what kind of return, you might say, the cyanamid company was looking for in the early days for whatever capital it might invest and whatever effort it might put into such an enterprise.

There were statements made on several occasions that to develop a fertilizer industry in the United States of the nature of the one which was then talked about, which could work in connection with preparation for nitric acid supply for war, would require such a large capital investment, and the return would be so problematical, unless there were some especially advantageous power conditions, that private capital could not take the risk, and that therefore the Government must go into it if it expected anything to be done.

With that preamble as to early history, we may jump, I think, right up to the time when the United States came into the war. The national defense act had been passed the year before—nearly eight months before—and several committees had been appointed by the President and the Secretary of War to advise as to how to act in that particular matter of the provision of fixed nitrogen for war needs, and the first committee had made a recommendation which looked rather to the ultimate future. It provided that we should improve the river at Muscle Shoals and get the power work started, which would take, they figured, something like four years, I think. It also contemplated an arrangement that concerns be invited to bid upon the power and come down there to use it for fixation purposes. That was the recommendation of the committee; there were other things, but essentially that was it.

Just about the time that the committee reported, in January, 1917, some information came out about the progress that had been made in the new synthetic ammonia process of the General Chemical Co. That was working in the laboratory of the General Chemical Co. on a scale which was very small. It was an improvised apparatus for experimental work only, and yet it was larger than the glass and rubber apparatus that the chemist generally makes his preliminary experiments with. But that apparatus had been tried by the General Chemical Co. sufficiently to justify them in drawing plans and placing orders for apparatus and for buildings for a plant in the neighborhood of New York, to cost somewhere in the neighborhood of $1,000,000.

Certain people represented to the Chief of Ordnance and to the Secretary of War that this process looked so promising that we had better go into it or at least we had better have it thoroughly considered. So a new committee was named, taking a great proportion of the old committee and adding more of it to reconsider that.

They thought that process was worth developing, and they recommended that it be developed, and that was finally approved in July, 1917, about four or five months after the United States entered the war.

It was recognized that that was no step of any consequence in the production of what we needed for the war, but it was a step which might lead to very large progress in the production for the needs of the war and it was considered by these gentlemen who formed that committee as being well worthy of trial. At the same time, whatever progress it did make would be highly desirable; and it was a step toward an achievement corresponding to what the Germans had made in the celebrated Haber process, of which we knew very little. The Haber process was kept distinctly secret and its patents were very strong, very broad, but they pretty effectually avoided such particularization as would enable anybody to make use of them.

At that stage of the matter the Ordnance Department set up the Nitrate Division, putting me in charge of it, to carry out that program of developing that process and at the same time giving us permission to inquire into a number of other processes so that we might have our eyes open to anything that was developing and be ready to take advantage of anything.

We went along on that project and started to build, and started an investigation of everything else we could hear about. At that time we felt that at any moment, with the development of the submarine campaign or even surface raiding, we might be deprived of our connection with Chile and our ability to bring in Chilean nitrate. In that case we would be badly up against it, and we felt that we must go counter to the recommendations of the commission in a manner and come back to what they had passed over, which was the use of the cyanamid process. So I started up an inquiry into it.

Along about September, 1917, we started into that matter, and we got in touch with Mr. Washburn and had several conversations with him; and there were some letters that passed, principally in the month of October, in which Mr. Washburn stated the conditions under which he would move in the matter. Those are already in evidence before Mr. Graham's Subcommittee on Expenditures in the War Department, under the Department of Ordnance. On page 2937 of their part 51, serial 6, is printed a letter which Mr. Washburn put in evidence, the letter of October 13, 1917, to the Nitrate Division, which was then called simply Division T of the Ordnance Department. There he stated the conditions under which he would do this work for the Government, as follows:

> Our charge for a detailed set of drawings and a general engineering study for a plant as outlined in our letter of October 5 would be 5 per cent of the total cost of the plant. The estimated cost of the plant is to be used as a basis for determining the preliminary payments for the work, and the actual cost as developed from the construction of the plant is to be used in determining the payment in full.

That was to be the compensation for a detailed set of drawings and a general engineering study. The letter goes on to say:

> There would be no charge to the Government for the use of our patents and processes for the manufacture of munitions of war nor for the use of our processes for the manufacture of fertilizer during the period of the war.

At the rate of 5 per cent on a plant which cost $65,000,000, speaking in broad approximations, the yield would have been $3,250,000, and as there was no reason to anticipate any deductions from that due to abnormal taxes that represented net profit presumably—I will not say net profit; there would be some expense, necessarily, in preparing the plans.

That was the first statement in the way of a price for which they would do the work for us.

That was followed later on by more specific proposals, which were brought about in this manner: Having had these preliminary conversations and proposals, we waited until something should develop which would necessitate action, and it came in October. I was out of town on business, and Col. White, next to me in the Nitrate Division, was informed by the Chief of Ordnance that there was urgent need for a large quantity of ammonium nitrate for use as shell filler, and that to provide that from any of the known materials by any of the usual methods of manufacture from the materials—not the chemical elements but somewhat more complex materials—was very much complicated by the fact that there was not a sufficient supply of either of the materials, sodium nitrate from Chile or ammonium sulphate.

They proposed, I think, at that time—shortly afterwards, if not at that time—to do what they could in the way of making ammonium nitrate by their methods, but they could not go very far, and so it was decided to try some fixation process to make the raw materials right in our own country, to be independent of foreign countries—a second Declaration of Independence, so to speak.

At that conference it was decided that we should go right ahead and call on the American Cyanamid Co. to see what they would do, more specifically about the particular project then in mind that had been covered by the previous letter, which I have just mentioned to you.

That led to several letters being exchanged. There was a letter of October 29 submitted by the American Cyanamid Co., signed by its president, Mr. Washburn:

> In continuation of ours of October 13 and in acknowledgment of receipt of your letter of October 23, etc., * * * understand that the object which the Government wishes to obtain, as far as the present discussion is concerned, is the securing of 1,000 tons of ammonia per week in the form of pure ammonia gas.

One thousand tons of ammonia per week, 52,000 tons per annum. The letter then went on to present three plans for supplying the Government's requirement. They all contemplated placing the ammonia plant—

> in northern Alabama, in the vicinity of Muscle Shoals, where eventually with the development of hydroelectric power at this point it may be practicable to operate the plant as a commercial industry in the manufacture of fertilizer. The American Cyanamid Co. is prepared to design, construct, own, and operate the ammonia plant and deliver the product to the Government at cost, plus an amount which will enable it to amortize the plant during the time in which it is engaged for work for the Government. The Government under these plans is expected to provide the capital necessary for the planning, construction, and operation of the plant without the payment of royalty or profits to the American Co. other than the amortization of the plant.

The letter proposed to do the work without any payment of profits, without any payment of royalties, for the work or for the patents of the American Cyanamid Co., except full ownership of the plant at the close of the war, which represented an expense to the Government of the complete cost of the plant, naturally, and represented to the American Cyanamid Co. such profit as they might be able to make out of it. That was, of course, problematical, as the letter goes on to say. But the proposition was to pass that right over to private ownership for the services of constructing it and for the privilege of operating it during the war emergency, which might last three years and which might last six months or which might be for about a week, as was our actual experience in this case. That was the compensation that was proposed by that letter, in its essence.

Senator KENDRICK. What was the proposed outlay there in the construction of the plant?

Col. JOYES. The proposed outlay would be, of course, something less than what is represented by the project that we actually went into, because, aside from any question of how much it cost for what was done or what was the proper cost of what we did, leaving that all aside, we did more than was proposed in this letter. We built an ammonium nitrate plant; this letter proposed an ammonia plant, to make ammonia.

Senator KENDRICK. Colonel, what I wanted to determine was how much was the estimated cost of that plant that would be turned over at the close of the war?

Col. JOYES. There were three plans submitted in that letter. The first provided for an ammonia plant, purchasing power delivered on the switchboard at the plant, and the cost of such a plant in normal times was in this letter estimated at $6,700,000, but to meet the war conditions of high prices it was assumed that it would cost $14,000,000. Then the circumstances of the times would also require housing provisions for the employees, not otherwise necessary, which would cost $1,000,000. It contemplated also the possibility that the Government would have to provide capital for an 80-mile transmission line at a cost of, say, $1,000,000. So that this letter estimated $16,000,000 as the actual cost for the Government to go into the work. That was an advance estimate, just written into a letter, not supported by detailed figures at all, and we may well assume that if we had carried out that project it would have been pretty nearly doubled, from the experience of what other work we did in the war.

The second plan submitted was for a nitrate plant—meaning, of course, an ammonia plant, to cost $14,000,000; housing, as before, to cost $1,000,000; and a steam electric plant to cost $4,500,000; the aggregate being, therefore, $19,500,000, roughly. The difference between that and the previous plan was that that had this self-contained steam power plant.

Plan No. 3 was based upon the Government's loaning to the local hydroelectric power company $2,500,000—that means the Alabama Power Co.—to be repaid by the power company at the rate of 3 mills per kilowatt hour for the power delivered at the switchboard, etc. On that basis the cost estimated for the Government's actual expenditure was $14,000,000 for the plant, $1,000,000 for the housing; a total difference of $15,000,000, plus a loan to the Alabama Power Co. of $2,500,000.

Those were the projects put up in that letter, and which led only so far as ammonia.

That was considered in a meeting in Gen. Crozier's office, then Chief of Ordnance, with the collaboration of a number of business men, some of them in the War Industries Board and some of them not; also several of Gen. Crozier's officers and some other Government officials outside of the department. It was, of course, noted that that was not exactly what the United States was after; that it wanted to go beyond ammonia; and, furthermore, that at first blush the proposition to give over a plant which the Government had built with public funds was one that could not be undertaken by any administrative or executive officer.

Senator RANSDELL. I am not very clear as to that. What was the company to do in consideration of this transfer to it of this very expensive plant? The Government was to build a plant; what was the company to do? Were they to furnish what we call the "know how"?

Col. JOYES. Yes, sir; the company was, in the language of the letter, to design, construct, own, and operate. In other words, the company would furnish, as you say, all the "know how" and all the patent rights which it had but incur no expense.

Senator RANSDELL. Nor any financial liability?

Col. JOYES. The matter of financial liability, if I remember correctly, was not gone into very much in that letter; no, sir. In a hasty glance over that letter I find no reference to it. It was in later letters, however.

Senator RANSDELL. Was the value of the patents considered? Were they considered of very great value, or was it simply the "know how" that they were going to furnish—getting this $16,000,000 or $19,000,000 worth of property for that "know how"?

Col. JOYES. Well, the value of the patents is something that I think nobody attempted to appraise in money value at that moment. The patents were good to all intents and purposes, and they have been standing throughout the world for a good many years. The patents are owned by an Italian company, and they are licensed out to users in all the different countries of the world. The American Cyanamid Co., as I understand—I do not speak from definite knowledge—but it has always been my understanding that the American Cyanamid Co. controls the rights under those patents for the so-called Frank-Caro cyanamid process throughout the American continent, certainly in the United States and Canada. We have never questioned their title at all.

Senator RANSDELL. Were those patents considered to be of very great value? Could you operate without them?

Col. JOYES. Not by that process. As I say, after some discussion of that letter and the determination that it was not a proposition which led us exactly where we wanted to go, and that it was not a proposition in the form that we could possibly accept it, Mr. Washburn was communicated with again and asked to make a modified proposal. Also, some inquiries were made in the meanwhile of builders and others as to the probability of the plant being built within the time which was held out. The talk was six months, about, for the first half of the plant to get into operation after the date of breaking the ground, and the second half within a further six months. That was pretty rapid work for a large plant, and we wanted to know what probability we had of making good on that time program before we went into anything at all. We wanted to have some assurance that the people were going to be able to carry it out, that they had the ability to carry it out, and that it was possible to carry it out. So all those things were gone into to some extent.

In this letter of November 5, 1917, addressed to that same Division T of the Ordnance Department, which was the nitrate division, the purpose stated is:

> To set forth a plan under which the Government may have ammonium nitrate manufactured for it from new sources of supply not now in existence; one-half of the plant, of a capacity of 55,000 tons of ammonium nitrate per annum, to be ready in six months from the date of breaking ground, and the remaining half of the plant, of like capacity, to be ready six months thereafter.

I read that preamble in full, because that is a full, clear-cut, short statement of exactly what we finally set out to do in the Muscle Shoals plant—this nitrate plant No. 2—a total capacity of 110,000 tons of ammonium nitrate, ammonium nitrate being a finished high explosive ready for use, a high explosive that at that time we were urgently in need of, because it was desired for use in shell filler along with some T. N. T., but to avoid the necessity of using all T. N. T. in the shell.

That went considerably further than the original plan for ammonia only, and in setting forth the project in this letter Mr. Washburn analyzed the process steps as follows: First, the manufacture of lime nitrogen—cyanamid; second, the conversion of lime nitrogen into ammonia gas; third, the oxidation of ammonia gas to nitric acid; fourth, the neutralization of the weak nitric acid to ammonium-nitrate solution and its evaporation to ammonium nitrate.

There were four essential steps in the process. The first was the making of calcium cyanamid, or lime nitrogen, as the American Cyanamid Co. was then doing in Canada, the only people who were doing that on this continent, and therefore the only people to whom we could turn for any working knowledge of it. Second, the conversion of lime nitrogen to ammonia gas. That is not so specific. That is principally practiced by that company, but also done by the Du Pont Co. and some others at that time. The third step was the oxidation of ammonia to nitric acid, something that was very little done in this country, I think probably only by this company. Fourth, the formation of the ammonium nitrate, the finished product.

I analyze that in that way, as Mr. Washburn did to some extent in his letter, to show you that the first process was strictly and solely one which the Cyanamid Co. controlled as well as had experience in; that the second and third were processes in which they had had some experience, although they could not be said to control those processes in full; and the final process was one which they neither controlled nor had any very considerable experience in, at least. I do not think they had ever made any ammonium nitrate, certainly not in any quantity.

The plan was submitted in three subdivisions. Subdivision A provided for an ammonia gas plant by the cyanamid process, the capacity of that plant to be 1,000 tons of ammonia per week and estimated to cost, under war-time conditions, $14,000,000, plus the necessary housing for the employees, not otherwise necessary, which would cost $1,000,000—$15,000,000 in all. For this ammonia plant, or ammonia subdivision of the main plant, the proposal was this:

> The American Cyanamid Co. will purchase land for, plan, construct, and equip the ammonia-gas plant, the Government power plant, and the Warrior River power plant extension.

Those power-plant provisions require no particular discussion at this time, I think. If necessary, I can come back to them.

The point was this: The company was to construct that plant complete and the Government to pay all the cost thereof, such cost to include every manner of expenditure made by the American Cyanamid Co. in connection with said plant, the constructing, equiping, and so on; all administration, overhead and general expense, and all taxes of whatever nature, including Federal, State, and county taxes on real estate and personal property; war, income, and excess-profits taxes:

> The American Cyanamid Co. will operate said plant for the period of the present war, and in any case for not less than three years, the money for all these purposes to be advanced and paid by the Government. The ammonia-gas plant, estimated above to cost $15,000,000, shall be and become the property of the American Cyanamid Co. The Government power plant and the land occupied thereby shall be and become the property of the United States Government. The Warrior power-plant extension, together with the transformer stations and the line, shall upon completion of payment therefor—

By the Alabama Power Co., presumably—

> become the property of the Alabama Power Co.

Now, taking that first subdivision of the pant, we see that the company was proposing to furnish all the "know how" and the patent rights, and nothing else, and the United States should pay every penny of cost, even to taxes. At the close of the war or, at the close of three years if the war were of shorter duration, the plant in toto to become the property of the American Cyanamid Co., a plant which at that estimate had cost the United States $15,000,000.

Subdivision B includes the nitric-acid plant, in which the nitric acid entering into the manufacture of the finished ammonium nitrate is manufactured by oxidizing ammonia:

> The site of the nitric-acid plant to be separated from and within convenient distance of the site of the ammonia-gas plant; the capacity thereof to be substantially 92,000 tons of nitric acid per annum. The cost of this plant under normal times estimated at $3,000,000, under present conditions $7,250,000.

The proposal as to this plant is later on in combination with that of subdivision C.

Subdivision C was to include the ammonium nitrate plant where the ammonia gas and the nitric acid were brought together to form ammonium nitrate, the capacity of that plant being substantially 110,000 tons of ammonium nitrate per annum. The cost of that subdivision under war conditions was at that time estimated to be $3,300,000.

Now, comes the proposal for subdivisions B and C; that is, the nitric acid plant and the ammonium nitrate plant:

> The American Cyanamid Co. will purchase land for, plan, construct, and equip subdivisions B and C, and will operate them all at the cost thereof. Said cost shall include every manner of expenditure made by the American Cyanamid Co. in connection with said planning, constructing, equipping, providing the land and operating, including the cost of materials and labor, administration, overhead, general expenses, Federal, State, and county taxes on real estate and personal property, but shall not include any part of the war and excess profits taxes of the corporation. The American Cyanamid Co. will operate said plant for the period of the present war or for not less than three years, these plants, the nitric acid and ammonium nitrate plants, to be and become the property of the United States Government. There shall be paid to the corporation as net profits to it for providing and operating the nitric acid and ammonium nitrate plants 15 per cent of the cost of the plants.

plus 10 per cent of the cost of the ammonium nitrate, exclusive of amortization, entering into the cost of the ammonium nitrate the necessary ammonia gas at 8 cents per pound.

The essence of the matter there is that for the constructing of these plants for making the nitric acid and for making the ammonium nitrate, and for operating them for the period of the war or three years minimum, the company was to get 15 per cent on the total expenditure of the United States, and also for the operating 10 per cent of the manufacturing cost of the product.

Now, to analyze that, you see that in that proposition, having gone beyond the production of ammonia, the Cyanamid Co. divided its proposal into two distinct forms of remuneration. The first form was for that part of the plant which they could use directly in a fertilizer business—the production of ammonia. Ammonia enters into fertilizer, and they could use it. So there their remuneration was the turning over of the plant to them in fee simple and after they had incurred no expense whatever in the construction of it, even for their taxes, all that they could think of putting down, and even the excess-profits taxes, which at that time, I think, were not very well crystallized but certainly not anything like what they are now. But it was understood they would amount to quite a little bit in the contributions of individuals to the Government. Even those were provided for; all excess-profits taxes were to be excluded; the company was not to have to pay out a cent for anything like that, and they were to get the plant in toto, every part of that plant that they were interested in—not the steam power producing plant or any of those power producing facilities, because they were for the emergency of the war, and the company would not have been able to use a steam power plant to make power cheap enough for that they wanted for this fertilizer business. So that would be left to the United States.

Senator KENDRICK. Col. Joyes, do you recall whether or not in this generous proposition on the part of the American Cyanamid Co. there was any reference made to patriotic motives?

Col. JOYES. I do not recall any, sir. The preamble is this:

> This letter is written in accordance with an understanding had with Gen. Crozier, Chief of Ordnance, at a conference in his office at Washington, Friday, the 2d instant. Its purpose is to set forth a plan under which the Government may have ammonium nitrate manufactured for it from new sources of supply not now in existence.

I find no other reference to it, only the implication from that preamble.

Senator KENDRICK. I am prompted to ask the question by the fact that in nearly every proposition made to the Government during the war that I can recall there was the statement that it was made on purely patriotic grounds, and I wondered if this very generous offer was made on the same grounds.

Col. JOYES. There was no such language in this letter, sir.

The CHAIRMAN. Col. Joyes, you are referring now to the $15,000,000 plant—the fertilizer plant?

Col. JOYES. This whole letter comprises a complete ammonium nitrate plant, just such as we have constructed there at Muscle Shoals.

The CHAIRMAN. What I had reference to was the fertilizer plant which the American Cyanamid Co. was willing to take over. That referred only to the fertilizer plant, which cost, as I understand you, $15,000,000?

Col. JOYES. It would, perhaps, not be quite accurate to say fertilizer plant, sir; but the particular portion of our plant that was to be turned over to the American Cyanamid Co. was the plant for making ammonia. Ammonia is capable of being used in fertilizer; it is almost a necessary step toward a nitrogenous fertilizer.

Then as to the other portion of the plant which looked directly to the military end rather than to fertilizer, the company did not desire to take title to that, but on that it asked a net profit, exclusive of its taxes and all such matters, of 15 per cent on the total cost of those portions of the plant, which were estimated in this letter at $3,300,000, plus housing for workmen of the nitric acid and ammonium nitrate plant, $350,000, making $10,900,000 as the estimated total cost of these facilities which were to be kept by the Government. Fifteen per cent on that would have been $4.635,000 net, except for taxes.

In this letter the next to the concluding paragraph stated:

> It is proposed to organize a separate corporation, under the name of the Air Nitrates Co., to conduct all the work and to assume all the obligations set forth in this proposal, the entire capital stock of which shall be owned by the American Cyanamid Co. The books and records of this company shall be subject to monthly audit by the Government, and it shall have advanced to it by the Government the necessary moneys in a manner so as to assure all of its operations against any delay.

That letter was discussed in the office of Gen. Crozier, and it was considered that that proposition was altogether beyond the bounds of consideration. In the first place, it was not possible for any administrative officer or for the President of the United States to pass title to anything like that created at the public expense; and, therefore, we never gave any serious consideration to it, but it was talked over with a view to seeing what might be a next step toward something that could be considered. There was some discussion with Mr. Washburn. I could not say exactly on what dates and exactly what persons were present on each particular day, but in the series of consultations and conferences between the latter part of October and the time, November 13, when the final proposition was submitted there were participating in these conferences several officers of the Ordnance Department, including Col. Hoffer, Col. White, and myself; Capt. Osborn—Alexander Perry Osborn, a lawyer, of New York. Maj. Runcie, a retired officer of the Judge Advocate General's Department, was either present in some of the conferences or was consulted outside of them on the project. Mr. Baruch came in; also Mr. Summers. Judge Brookings, I think, of the War Industries Board, at one time was in there. Dr. Parsons, of the Bureau of Mines, was present at one time.

In other words, Gen. Crozier made it a point to bring together all the men of experience in large business that he could get hold of, in addition to those who are experienced in the transactions of the Government, to try to find a way out of the difficulty so that we could start to build a plant.

The next proposal after that was dated November 12, and that was submitted after considerable argument with Mr. Washburn by all these gentlemen, explaining to him the difficulties in working along the lines that he had proposed and urging him to put up something that would come within the possibilities. This letter of November 12 starts in by saying:

> There have been many conferences * * * and it will be most helpful to all concerned if we now set forth in writing the history of the company and the proposals so far considered.

Then he goes on to show how the American Cyanamid Co. manufactured its first product in the latter part of 1909, and so on; had invested capital in this enterprise now upward of $12,000,000; annual output at prevailing market prices of the value of about $12,000,000; made repeated attempts to locate a plant within the borders of the United States. and so on.

Then he went into some discussions of the Government's steps, how they had been brought before some of the committees to advise them and give them information, and then—

> The American Cyanamid Co., despite all its endeavors, in the face of the serious war conditions with which this country was confronted, failed to impress the officials of this Government with the importance of a large, independent, domestic production of pure ammonia and nitric acid.

Then came the urgent necessity, in the fall of 1917, when they were called upon to help out.

Senator **Kendrick**. From what are you reading, Colonel?

Col. **Joyes**. I am just taking a few bits here and there from this letter of November 12, 1917, from Mr. Washburn to Gen. Crozier. This is all a preamble to a proposition which is contained in the same letter. He then says:

> It is also apparent that the only practicable means of meeting this situation is the immediate construction of a great ammonium nitrate plant for making explosives by the cyanamid process, and it is necessary to the military plans of the United States that this great plant shall be ready for operation to about half its capacity within six months and the remaining half within an additional six months. The American Cyanamid Co. is the only one familiar with and experienced in this process on the American Continent. It is also apparent that should the Government own and utilize this $30,000,000 plant after the return of peace they would completely destroy a business in which the American Cyanamid Co. has expended millions of dollars and many years of continuous effort in widening its market.

All that going to show the existing interests of the American Cyanamid Co. and how they would be endangered by the construction of a Government plant. He then goes on to defend that point of view. He says:

> The last proposal from the Government is that the American Cyanamid Co. shall design, plan, construct, and operate the proposed new Government plant under a guaranty that neither the plant nor any of its equipment shall be used for any except military purposes without paying royalty. Under this plan the American Cyanamid Co. is to receive from the Government no compensation and is to receive only a sufficient amount of money to pay for the time of its staff given in the construction and operation of the Government plant and an amount to make good to it the loss and disadvantages to the company from breaking up its organization. We hesitate to believe that the Government has made any such arrangement with any other company. * * * We therefore now transmit as a part of this communication the proposal heretofore orally presented and which we have reason to believe was originally favorably received.

Then comes the proposal:

> The American Cyanamid Co. will cause to be acquired, constructed, and operated, as hereinafter stated, a plant for the manufacture of ammonium nitrate of a capacity of 110,000 tons per annum, estimated to cost $30,300,000.
>
> * * * * * * *
>
> It is proposed to organize a separate corporation, under the name of Air Nitrates Corporation, to undertake all the work and all the obligations set forth in this proposal and be solely responsible to the Government therefor. The corporation shall have sufficient rights with respect to the patents and processes of the American Cyanamid Co. to perform the obligations provided herein. The corporation will plan, construct, equip, maintain, operate, and conduct the business in connection therewith on the following terms:
>
> Item 1. The American Cyanamid Co. will turn over certain of its executive and technical officers.

Some 9 or 10 of these men.

> Item 2. The American Cyanamid Co. will give the corporation sufficient rights with respect to patents and processes to enable it to construct and operate for the period of the present war.
>
> Item 3. The American Cyanamid Co. will place at the disposal of the corporation for the production of ammonium nitrate and the construction and operation of the plant by it all the company's experiences * * *, etc., and all the things set forth in this paragraph—

That is, the furnishing of experience, records, etc.—

> shall be done at the expense of the American Cyanamid Co.
>
> Item 4. The American Cyanamid Co. will place its various plants at the disposal of the Government for giving the preliminary training to men.
>
> Item 5. The corporation will construct the plant and all things in connection with it, and contract with various parties for work, material, etc., on the basis of upset prices, unit prices, and cost-plus percentage, as in each case may be deemed most advantageous to the Government.
>
> Item 6. The corporation will give preliminary manual training to the operatives. * * *
>
> The Government shall supply all the money necessary for the various purposes at such times and in such manner as to allow all the corporation's activities to proceed without delays or interruptions. The corporation shall receive 9 per cent on the cost of constructing and equiping the plant and of conducting the business in connection therewith. Said cost estimated roughly at $30,000,000. The limit of said 9 per cent payment shall be $2,700,000. Cost shall include all manner of expense, including administration, superintendence, rentals, insurance, liabilities, losses not covered by insurance, and all overhead general and legal cost and expense; excluding, however, all items whose cost as specified above is to be borne either by the American Cyanamid Co. or the corporation.

Items 1, 2, 3, and 4 are the special items of assistance to be given by the corporations.

Senator KENDRICK. Did they overlook the taxes in that provision?

Col. JOYES. Taxes are not mentioned; sir.

The CHAIRMAN. This is the proposal that was accepted, is it, Colonel?

Col. JOYES. No, sir; not quite that yet. This provided a fee for this construction work of 9 per cent, with an upset limit of $2,700,000. That is, the upset limit was equal to 9 per cent on the roundly estimated cost of the plant. The plant was to be and remain the property of the United States in toto, but no rights were conveyed to the United States for its use after the war.

Senator KENDRICK. Now, we are getting to the proposition that was accepted?

Col. JOYES. Not quite; sir. There was one other provision in this:

> That the corporation shall receive further an amount equivalent to one-half cent per pound of ammonium nitrate produced, and the Government at the expiration of the period of operating of the plant under this proposal shall cooperate with the American Cyanamid Co. and the corporation to the end of enabling the former to recover its staff and former employees which had been placed at the disposal of the Government.
>
> The company stands ready to consider a counterproposal, to the effect that it shall provide and perform all the things set forth in the preceding proposal and accept as its net return therefor that portion of the plant which is known as the cyanamid or ammonia gas plant, in which event the Government would be expected to stand the cost of all the items above numbered 1 to 6 inclusive, except item 2.
>
> In this event also, in order that the plant might have some prospect of commercial value after the war, it should be specified that it will be placed at Muscle Shoals. In this manner the company would have proper protection for its cyanamid and ammonia gas processes, although it would not then gain protection for its nitric acid processes. The value of the ammonia gas plant, on the assumption of three years' use before the close of the war and the further assumption of commercial applicability after the war, would be, after deducting 10 per cent per annum depreciation from the prewar cost, about $3,800,000 as nearly as can be predetermined. Under this proposal the American Cyanamid Co. will suffer consequent losses of $1,000,000 per annum, as nearly as can be determined, and even if the part of the plant belonging to the company had value, the company probably would not more than break even.

You see, that is intended to show, from the company's standpoint, how little value they would be receiving, and it proceeds upon this assumption of 10 per cent per annum depreciation during the three years of war. That proposal was not considered favorably; it was considered.

Senator KENDRICK. All this was to show the sacrifices they were making in all those propositions?

Col. JOYES. Yes, sir. After that proposal was submitted there was considerable argument with Mr. Washburn, and he was told that nothing could be done on that basis, and that something better would have to come up if we were to get anywhere on the matter. The following day, November 13, was submitted the proposal which was finally accepted, offered as a substitute for all previous proposals.

As before, it proposed to organize a separate corporation under the title of Air Nitrates Corporation to conduct all the work and undertake all the obligations, the corporation to have sufficient rights with respect to the patents and processes of the American Cyanamid Co. to perform the services provided for; all books and records open to monthly audit, and so on:

> The corporation will plan, construct, equip, maintain, make preparations to operate, and deliver the product to the United States Government, f. o. b. cars, on the following terms:
>
> Item 1. The American Cyanamid Co. will take place at the disposal of the corporation the following members of its executive and technical force: President, vice president, general manager, engineering assistant to general manager, superintendent of manufacturing, sales and traffic manager, chief technologist, chief engineer, assistant engineer, and two principal works managers. In addition thereto, for the operation of the plant, the American Cyanamid Co. will pay the salaries of the persons mentioned.

I mention that because it shows that this proposition contemplated that the salaries of those people who were furnished for this work should not be paid either by the United States or by the Air Nitrates Corporation. [Reading:]

> Item 2. The American Cyanamid Co., without charge, will place at the disposal of the corporation for the production of ammonium nitrate and the construction and operation of the plant by the corporation all of the company's experiences, records, studies, etc., bearing in any way upon the production of ammonium nitrate.
>
> Item 3. The American Cyanamid Co., without charge, will place its various plants at the disposal of the corporation for giving preliminary training to superintendents, etc.
>
> Item 4. The corporation will design, make plans and drawings for, lay out, erect, and construct the plant, and all things in connection therewith, purchase and install all the equipment, etc.
>
> Item 5. The corporation will give preliminary manual training, as above described, to certain of the operatives, etc., and engage in all the business and activities in connection with this plant up to the 1st day of June, 1921, and for the period of the present war. It will use its best efforts to the end of accomplishing these things at the least practicable cost consistent with the demands of the Government on the plant.

Those were the five items. [Reading:]

> The Government shall bear the entire cost of conducting the business and activities of the corporation, excluding, however, any cost in connection with items 1, 2, and 3, and shall supply the corporation with all the money necessary to conduct its business, in such amounts and in such manner as to allow all the corporation's activities to proceed without delays or interruptions and without the necessity of the corporation providing any capital or assuming obligation for borrowed funds.
>
> Item A. The Government shall make payment to the corporation of a fee equivalent to 3½ per cent of the cost of constructing and equipping the plant and of conducting the business and activities in connection with construction and equipment. The limit of such payment shall be $1,000,000. The cost, as used in the preceding paragraph, shall include all manner of expense to the corporation—

Including even legal cost and expense, but not mentioning taxes.

Senator KENDRICK. Colonel, was this proposition that you finally accepted submitted at the same time the others were submitted, so that you could take your choice?

Col. JOYES. No, sir.

Senator KENDRICK. I did not understand that they were, but I wanted to be sure of that.

Col. JOYES. I read in this letter the statement:

> This proposal is a substitute for all previous proposals to the Government, both written and verbal.

After specifying the nature of the cost which was to be carried by the Government and upon which the fee of 3½ per cent was to be computed, item B of the remuneration was stated:

> The Government shall pay further to the corporation a fee of one-quarter cent per pound of ammonium nitrate produced. Further, the Government shall pay to the American Cyanamid Co., as royalty, an amount equivalent to 6 mills per pound of nitrogen fixed as lime nitrogen.

Now, that royalty, stated as 6 mills per pound of nitrogen, amounts to just about the same thing as the operating fee of one-quarter of a cent per pound of ammonium nitrate. It comes to very nearly the same thing, so that to all intents and purposes of accuracy you may say that the operating and royalty fees together carried a charge of about half a cent for every pound of ammonium nitrate turned out. And the construction, for creating the plant, was on the basis of 3½ per cent of the total cost of it to the United States, limited, however, to $1,000,000.

Senator KENDRICK. Colonel, pardon me a moment; I think it is important to know this: Are you going to develop the obligation of the Government to the company after the expiration of the war under this contract?

Col. JOYES. Yes; I am coming to that right now.

Senator KENDRICK. I think that is very important.

Col. JOYES. The answer to that question is that this proposal omits all mention of the future. This proposal was quite silent on that. It only touched upon the period of operation during the war and provided that if the war should close earlier it should run at any rate to June 1, 1921. That was the proposal which Mr. Washburn was finally induced to come down to from the previous ones.

Senator SMITH of South Carolina. This, your final contract with him, the one under which you ultimately operated, as I understand, runs up to 1921. What were the terms of that contract?

Col. JOYES. The terms of that contract were, of course, worked out from this proposal and were expected to embody that proposal, with such reconciliation of the different views as to the language on certain points as had to be made. The final contract was dated November 16, 1917, and essentially followed that proposal, but it did contain a clause for the future; that is, if the war continued. That clause was this, that the United States should not operate the plant using any of the American Cyanamid Co.'s patents without making adequate compensation for them.

That is a provision that has been very seriously criticized from the point of view of the Government, and at the time I signed that contract—although I did not draw it all; it was drawn by lawyers, but I had been in touch with the work all the time, had made suggestions, and looked it over—I rather liked that provision. I thought it was about the best way to leave it. Neither the American Cyanamid Co. nor the United States officers could well tell at this time what the process would be worth either to the United States or to the company after the war, and it was a better proposition to leave it to be settled by negotiations, by arbitration, or by the courts.

Senator SMITH of South Carolina. What was said in reference to use of it after the war?

Col. JOYES. I dislike to speak that way of a contract without reading it from the contract, but I am pretty positive as to that, sir, that it said that the processes of the American Cyanamid Co. should not be used without adequate compensation. It was made clear in the contract that the plant was the property of the United States. That was the fundamental that we insisted on right straight through, and the rights to the patents were very clearly defined for the period of the war and in any event until June 1, 1921. And it was perfectly clear under that first contract, dated November 16, 1917, whatever the exact phraseology was, that we had no right to the use of the patents unless we made adequate compensation, that being left to future determination. There was no specification, then, as to the amount or method of determining adequate compensation.

The CHAIRMAN. That is very important, Colonel. As you understand the terms of the contract, the Government would have no right to use these patents under this contract after the war without entering into a new agreement with the American Cyanamid Co.?

Col. JOYES. Not necessarily—without adequate compensation.

Senator SMITH of South Carolina. You could go on and use them, but you would be under obligation to give them proper remuneration?

Col. JOYES. Certainly. There was no permission given to use them; the language was negative in its form, that the patents should not be used without the payment of adequate compensation.

The CHAIRMAN. Of course, the result of that might be that we would have to resort ultimately to arbitration or the Court of Claims.

Col. JOYES. I was perhaps not following closely enough the thought you had in your mind. This is the contract we are talking about now—the contract of November 16, 1917. That is the contract under which we started to work and kept going until June 8, 1918. At that time, however, there was a superseding contract written—an entirely new contract—and while I answered perfectly correctly for the provisions of the original contract, I did not for those of the one in force. They have been superseded by the contract of June 8, 1918. That was negotiated when we thought it necessary to build two additional plants, and it was decided to write a superseding contract covering all three plants—Muscle Shoals and the two proposed new ones. In that contract there is a provision for the future. In that contract there is a specific provision of a stated royalty to be paid after the termination of the war, in case the United States manufactures at that plant.

Senator SMITH of South Carolina. And uses those processes?

Col. JOYES. Yes, sir.

Senator SMITH of South Carolina. That contract is now still in existence?

Col. JOYES. Oh, yes.

Senator SMITH of South Carolina. It has no definite, specific limitation on it?

Col. JOYES. No, sir.

The CHAIRMAN. Will you kindly give to the committee your interpretation of the terms of that contract?

Col. JOYES. The terms of this present contract of June 8, 1918?

The CHAIRMAN. The one in existence now.

Col. JOYES. I have not it here with me; but I can, I think, give you something that will not be misleading. The idea was that for the additional work that was to be performed the Government should not pay in strict proportion as it had been paying. That is, if we paid $1,000,000 fee for plant No. 2, at Muscle Shoals, and we were going to put up two new plants exactly doubling that capacity, we should not pay double the fee. The amount of the fee had already been criticized in a good many quarters, and it was felt that if we went into new work we should have some modification of it; in other words, that no one should get quite so much out of Government work.

So, for this doubling of the capacity the Cyanamid Co. and the Air Nitrates Corporation finally, after much persuasion, agreed that they would accept as a construction fee one and a half times what had been agreed upon for No. 2 plant—the first plant started.

That is, for the percentage rate applicable to plants 3 and 4 the United States desired, instead of paying 3⅓ per cent, to pay 1⅔ per cent of the expenditures for plants 3 and 4.

However, Mr. Washburn, while agreeing in principle to the theory of a reduction in fee for the additional work to half the rate on the preceding work, refused to put it in just that language, and I was strongly inclined to decline to recommend the approval of that last contract because of that fact. But we had had so much trouble with it and we so much needed to get ahead with the work that I finally gave my indorsement to the contract.

The difference is just this: In that new contract the language was that up to an expenditure of $30,000,000 on any of these three plants the rate of fee should be 3⅓ per cent and that on amounts above $30,000,000 the fee should be 1⅔ per cent. Now, that results in just this: Immediately your cost of No. 2 plant exceeds $30,000,000, which was roundly estimated in the hurried first steps of the game, as a probable first cost for it, as it was at the time of the signing of that second contract, on that excess cost you are paying an additional fee over and above what you had agreed to pay for that plant originally. Do you get the point?

The Chairman. I understand.

Col. Joyes. So that we did not get what we were after. It was not very satisfactory, but we felt that we had every reason to trust the good faith of the company; that they would go ahead and work just as energetically upon plants 3 and 4 as upon plant No. 2 and that therefore there was not any very great point in having any whip over them, so to speak, in that additional 50 per cent of their pay strictly, but solely upon accomplishment at plants 3 and 4. So we waived that objection and signed the contract. Ultimately, you see, it would work out to the same thing if all three plants were completed. There would be $1,500,000 paid in any event, and that was $500,000 more than we had originally agreed to pay for plant No. 2. So it amounted to the same thing. We failed to have the whip over the contractors for accomplishment; that was the objection to it.

Now, that was the remuneration for building the plant. In the same way there was to be a larger quantity of material produced, and it was argued by the Government people that on a larger quantity there should be a reduction in the proportional payments of royalty and of operating fee. And it was provided that up to the capacity of the No. 2 plant at Muscle Shoals the original operating fee of one-quarter of a cent per pound of ammonium nitrate should be paid and that when the amount of nitrate produced by the corporation should exceed the original capacity of plant No. 2 at Muscle Shoals then we should pay not that full amount of royalty and that full amount of operating fee, but one-half as much per pound. Those conditions were to run up to June 1, 1921, or to the termination of the war if it were later than that.

At the same time there has been a good deal of criticism of the point in the original contract—which, as I say, I shall always feel was for the best—that we had not provided in any shape or manner for the future operation of the plant, and, therefore, it was urged upon the American Cyanamid Co. that they gave us some definite arrangement for the future, after the war. Well, they made that just about double the other; it was a cent and a half per pound of nitrogen fixed in any of the forms in which we might fix it in the plant.

Secretary **Baker.** As royalty.

Col. **Joyes.** That cent and a half per pound of nitrogen, paid as royalty to the Cyanamid Co., was just about twice what the preceding royalty had been, the preceding royalty having been originally stated as 6 mills per pound of nitrogen fixed in any of the forms which we used. You see, that is not the same thing as the pound of ammonium nitrate; it is the nitrogen content of the thing produced.

So that is the provision for the future as it stands in the contract now in force.

Senator **Kendrick.** Then that provision protects the Government and the company; or rather, it extends to 1921?

Col. **Joyes.** After 1921.

Secretary **Baker.** And after the war.

Col. **Joyes.** After the war; but to apply in any event to June 1, 1921, if the war had earlier terminated.

Senator **Kendrick.** I want to get this clear, Colonel. Would this become then a more or less perpetual royalty after 1921, or would it terminate with 1921?

Col. **Joyes.** If some one has a copy of the contract it would be much more satisfactory to refer to that particular point, but my remembrance is that there was no limitation upon it. Of course, there would be some limitation, due to the life of the patents, but I do not recall that any particular set date of limitation was in the contract.

Senator **Smith** of South Carolina. In other words, just as long as you operate this plant and use those processes you are to pay that cent and a half?

Col. **Joyes.** Yes, sir. This is the way we meet that. Of course, we were not indifferent to the fact that the patents expire some time, and we would naturally have looked for a way to set some limitation upon it, and that limitation was this.

The contract provides that after the war, or after 1921, at any time that either party becomes dissatisfied with this arrangement they may ask for arbitration. Each party provides one arbitrator and the two select another, and in case of doubt there are certain ways to select a third. Then those arbitrators decide the question as to what royalty shall be paid thereafter. Of course, if both parties are satisfied and go right ahead there is no arbitration. In case either party becomes dissatisfied at any time during the life of the contract, then they have the right to claim arbitration, and arbitrators are appointed under the arrangement in the contract, and they settle what the royalty shall be. Of course, when we approach the point where all the valuable patents are expired, or if for any other reason we desire to have arbitration, we can claim it.

Senator **Smith** of South Carolina. As I understand it, after the termination of the war the Government pays all the employees, it owns the plant, runs the whole business, and simply pays the Cyanamid people a cent and a half a pound for the use of their patented processes?

Col. **Joyes.** Yes, sir.

Senator SMITH of South Carolina. So that the Cyanamid people have nothing in the world to do with the plant, nothing to do with the operation, nothing to do with the output; they simply get the royalty of a cent and a half a pound?

Col. JOYES. That is the way it is set out in the contract, sir.

I think that possibly covers the ground of the several proposals leading up to the contracts and the contracts.

Senator KENDRICK. The committee has been told by more than one witness that the rights to the patents terminate in 1931 or 1932, I am not sure which.

Col. JOYES. I would not venture to say, sir. The patents, as you know, are never one single patent covering all that you want to do; there are a great many patents involved, and there are some of them that have a different application to the process from the others. Some are vital and some not vital. When a man starts in with a process that he has a general patent on he immediately proceeds to embroider it with other patents from year to year, so that he will always have something. That has generally been done.

Senator SMITH of South Carolina. So that the only relief is for the Government, through some of its agencies, to develop these subsequent patents and engraft upon the original patent something that will make that independent of whatever subsequent patents the company may have. That would be the only relief they would have?

Col. JOYES. It would be a hard thing to do, because you have a lot of interference all along the line there.

Senator SMITH of South Carolina. I can see that. Now, I want to ask you this question: The contract with the Cyanamid Co. is still in existence?

Col. JOYES. Yes, sir.

Senator SMITH of South Carolina. And you are living up to it?

Col. JOYES. Yes, sir.

Senator SMITH of South Carolina. I just wanted to understand clearly why we are taking so much time here, when the Government owns the patent, has a contract with the owner to use his patents, is living up to that contract, and it is in the hands of Congress as to what subsequent legislation they shall have.

Col. JOYES. It seems to me it is pretty clear, sir. The first proposals of the American Cyanamid Co. for building a plant were that they wanted protection, and they would get that protection and at the same time be recompensed for all their effort by owning the plant. Finding that we could not possibly do that for them, they come around and ask for the protection in another form. They put their protection and recompense in the form of a royalty or operating fee. It has been paid, essentially; we have not quite settled up on the construction fee yet. But there has been very little operation, so they have gotten very little royalty out of it thus far. If we operate now they will get a royalty, according to the contract.

Senator KENDRICK. There has been a good deal of testimony, Senator Smith, offered here indicating that for the Government to continue to operate this plant, or to begin operating it, for the purpose of producing commercial fertilizer, as I understand it, the company would be not only unprotected, but would actually be very badly injured by that fact; and what we wanted to do was to determine, first, where the obligation lay with the Government and with the company.

Senator SMITH of South Carolina. You can see that if the Government goes on and operates this plant, under whatever method it sees fit, and produces this stuff, that would injure the cyanamid people.

Senator KENDRICK. The idea in asking these questions was to determine where the rights of the Government began and those of the company left off, and just as nearly as possible the members of the committee wanted to know the terms of that contract so they could form their conclusions.

Senator SMITH of South Carolina. Bringing it down to its last analysis, according to the testimony, Colonel, the obligation of the Government is that having the plants now practically constructed, or the facilities for completing the construction, etc., they will use this company's processes, and on whatever amount of nitrogen they produce they will pay 1½ cents a pound. That is the situation now?

Col. JOYES. Yes, sir.

Senator SMITH of South Carolina. And it is wholly now with the Government as to whether they will go on and in what manner they will go on to utilize these processes owned by this company. It seems to me that is simple enough now if the statement made by the Colonel is exactly in accordance with the facts.

Senator KENDRICK. It is greatly simplified by his statement, which indicates that the Government has an actual contract with these people by which it may proceed in a perfectly legal way to operate this plant; but the testimony offered here indicated that there had been, if not a legal obligation at least a moral obligation violated, or that there would be if the plant were operated. Have you not understood it so, Mr. Chairman?

The CHAIRMAN. Yes.

Col. JOYES. I think I could go through the contract, if you wished, and find a number of little hints in it of provisions that were made about the operation of the plant by the Government to produce certain different products, and so on. We always aim to make our position as secure as possible, of course, and the other side wanted to give as little as they could, naturally. But in going over it we talked, and talked, and talked, day after day, with very good people on our side—Mr. McRoberts, brigadier general, who is now manager for the National City Bank, you know; and Mr. Burchard, vice president of the General Electric Co., both good business men, met Mr. Washburn and his people, and we argued with them a great deal, at a great waste of time, to get a contract that nobody would throw stones at the way they had done at first.

We did not know whether we should ever want to do anything with it or not, and yet we had to write such a contract, if we possibly could do it, that would give the Government some protection of its rights as well as give the Cyanamid Co. some protection of its rights. We could not have it all for the protection of the Cyanamid Co.

Senator SMITH of South Carolina. As you understand this contract, in whatever form you might produce this nitrogen, whether as sulphate of ammonia or pure nitric acid or what not, your obligation to the Cyanamid people is a cent and a half a pound for the nitrogenous content of whatever you produced?

Col. JOYES. That is right, sir, provided we use the Cyanamid Co.'s rights and processes—and it is hardly worth while mentioning that qualification, because with the plant we have you could hardly do anything else.

I do not think I am expected to go very far afield into the question of policy as to whether the plant ought to be operated or not. There has been some discussion as to whether private capital ought not to come in and produce all of the fertilizer that the country needs, and all that.

Secretary BAKER. I think, Colonel, you had better leave that to be covered by Maj. Gaillard.

Col. JOYES. I had just one reference here that I found in the record.

Secretary BAKER. I think it would be better to let that be covered by one statement. Maj. Gaillard has that all worked out.

Mr. WASHBURN. Mr. Chairman, do you want to hear from me at this time on the matter of the contract and my statement to you that the company desired no profit out of its war work, or do you want me to come back and give that to you later? I am wholly indifferent; I am simply asking the question.

The CHAIRMAN. The committee will be very glad to hear you, Mr. Washburn, but I do not know whether the Government experts would prefer to conclude their statements.

Gen. WILLIAMS. Yes, Mr. Chairman; we would like to conclude our presentation first.

The CHAIRMAN. Of course we shall be very glad to give you an opportunity, Mr. Washburn.

Mr. WASHBURN. I trust you will appreciate that I do not offer to come in here now, but I did not know whether it might suit the convenience of everybody or not.

Secretary BAKER. It is better for us to go ahead and cover all these points.

The CHAIRMAN. Then you may proceed, Mr. Secretary. The committee is very much obliged to you, Col. Joyes.

Secretary BAKER. May I make a statement or two, Mr. Chairman, at this point?

The CHAIRMAN. Certainly.

STATEMENT OF HON. NEWTON D. BAKER, SECRETARY OF WAR.

Secretary BAKER. I am doing this somewhat out of order, Mr. Chairman, because I am not able to be here long. There are two or three aspects of this question to which I understand Mr. Washburn had testified upon which I want to say or word or two.

I understand that Mr. Washburn in his testimony has stated that the present plan of the War Department contemplates an investment of $38,000,000 of new capital in order to salvage a plant having a replacement value of $15,000,000. I was not here when he said that, but I understand that is what he said.

The $38,000,000 to which Mr. Washburn evidently has reference covers the $12,500,000 proposed to be expended under authority of the act now under consideration. That, however, is not $12,500,000 of new capital, but is $12,500,000 worth of Chile saltpeter, which we will be able to sell and apply to this use, and which we should otherwise have to keep as a reserve if we do not operate this plant.

Senator KENDRICK. May I interrupt you there, Mr. Secretary?

Secretary BAKER. Certainly.

Senator KENDRICK. I recall, if I am not mistaken, Mr. Wasburn's statement that under the present condition of the plant—or I will say the possibilities of the plant—the Government would not be justified in parting company with those nitrates and depending at the same time upon producing a supply of its own. Was that your statement, approximately, Mr. Washburn?

Mr. WASHBURN. Yes; I raised the question, Senator Kendrick, as to the possibility, or feasibility rather, of disposing of 150,000 tons of nitrate in case the Muscle Shoals plant should be started up in operation.

Secretary BAKER. That involves a question on which Mr. Washburn's judgment is second; the judgment of the military experts is first on that, and following the usual rule of evidence, I suppose we should take the best evidence when we can get it. I believe the Ordnance Department's judgment as to what they need in the way of available nitrogen is better than Mr. Washburn's.

Senator KENDRICK. I thought it would be a good idea to call your attention to the fact, because he indicated, as I understood his meaning, that it was hardly possible for this plant to reproduce any material amount of the nitrates that were sold.

Secretary BAKER. I will ask Col. Burns or Gen. Williams to refer to that aspect of it.

Senator KENDRICK. I will not interrupt you further.

Secretary BAKER. The second item of the $38,000,000 is the cost of the hydroelectric plant, $25,000,000. Now, we have already spent $7,000,000 in the building of that dam. The dam was proper to be built, even if we had never had a nitrate plant at Muscle Shoals. If there is one thing which this country must do and do soon, it is to develop its water powers. The exhaustion of the coal supply and the exhaustion of the labor supply of this country, which are being absorbed now in the mining and transportation of coal, have no other such obvious relief as the development of hydroelectric power. It saves mine labor, it saves transportation labor; and the enormous economy with which high tension electric energy can now be distributed and the low line loss make the development of hydroelectric power in this country perhaps the greatest conservation measure and policy which the country has before it in any form.

And if we do not develop our water powers, we will be behind every other country in the world. France, hard pressed financially as she is, and Italy, flat on her back financially as she is, are, both of them, already expending very large sums of money in developing water powers infinitely less valuable and less productive than the great Tennessee River project. If we never had in contemplation the use of any nitrogen for either military or agricultural uses, the development of the water power at the Muscle Shoals rapids would be a policy of national conservation and economy that only the Government is able to carry out and only large enough to carry out.

So that the expenditure of $25,000,000 to carry out the Muscle Shoals project is not new capital for this one enterprise in any sense. As a matter of fact, the primary 100,000 horsepower which are to be developed at the Muscle Shoals dam will be used by this nitrogen plant for the manufacture of fertilizer. The next 100,000 horsepower which will be equally available by the supplementing of the dam at low stage with the already constructed and operated steam plant, will be available for distribution for industrial uses throughout that whole section of the country. As a matter of fact, the engineering estimate of the total power available from this dam at Muscle Shoals is neither 100,000 nor 200,000, but 375,000 horsepower.

What the Muscle Shoals Dam really means is a saturation of power at a low-development cost in one of the most promising regions of the United States for immediate industrial expansion and development, and an economy in coal production and transportation that is almost incalculable in its value to the general industrial situation of the country.

In addition to that, if that argument were not conclusive, as it seems to me it is, the Muscle Shoals Dam would be built, anyhow, for the development of navigation on the Tennessee River. That is one of the largest rivers in America and opens up new fields of coal and iron ore, and offers a cheap mode of transportation in a country where we have not as yet so overlaid the country with railroad facilities that there will be any real competition. The navigation of the Tennessee River is one of the really hopeful, forward-looking projects of the country, and the engineers estimate that $8,000,000, or any cost that that dam entails would be justified as a navigation project apart from its value as a power-producing project. So that to include $8,000,000 for the Muscle Shoals Dam as an element of new capital going into the nitrate plant seems to me quite inadmissible.

Senator SMITH of South Carolina. Is that the estimated cost of the dam—$25,000,000?

Secretary BAKER. Oh, it will be a great deal more than that, Senator. We have expended there $7,000,000. We have there now the preliminary dams. We have roads. We have the concrete bridge. We have the houses for laborers. We have everything there now, except sunshine and low water, to build the dam. And a part of it is built. If we were to stop and scrap the Muscle Shoals Dam it would mean wasting the $7,000,000 we have already expended, and it is inconceivable that we shall have, very shortly at least, more favorable labor and industrial conditions for the carrying forward of that project.

The CHAIRMAN. If I may be pardoned the interruption, Mr. Secretary, I think the comment arose in connection with the cost of production of nitrogen. Mr. Washburn is here himself, and he can state it very much better than I possibly could, but it was to the effect that the Government ought to figure 5 per cent on its capital investment, because it cost the Government at least 5 per cent. If I am misquoting your statement, Mr. Washburn, I wish you would correct me. As I understood you, it was this: You questioned whether this was the right time to do the work, to make the improvements, because of the high cost of labor and the high cost of material; because, if you take the cost into consideration and figure on the basis of 5 per cent, the products would necessarily cost more than the figures given by the Government experts.

Mr. Washburn. That is correct, Mr. Chairman.

Secretary Baker. Mr. Chairman, if that be the point of the argument, rather than the one to which I was addressing myself, the fact about it is that the sale of hydroelectric power from that dam, conservatively estimated—let me see if I have it here. There will be a surplus of 100,000 horsepower for sale at $12.50 per horsepower, which makes $1,250,000 as an earning; and if we sell the secondary power, or sell that surplus 100,000 horsepower at a higher price than $12.50, then, of course, we go above the $1,250,000 as an earning, which has to be taken in connection with whatever price we charge for the nitrogen as the net earnings of the hydroelectric plant. I have the figures here, I think, but I will ask somebody else to present them, because I want to deal only with the general aspects of the problem and the figures are not familiar to me.

But in working out the prices at which they propose to sell the product, I ask you to recall that although long-time firm contracts are now being made in this country for sulphate of ammonia at $90 a ton, all the calculations of cost and profit which were submitted to you at the previous hearing before this committee by my associates are based on a selling price of $65 per ton. Now, if the market is such that the $90 price, or any approximation of it is available to the Government, the profit is enormously increased upon the output.

There is one other consideration. I think it is perfectly proper for me to say—and Mr. Washburn will not be offended—that the people who do not want the Muscle Shoals dam built are people who are interested in power monopoly in the southeastern part of the United States. I think Mr. Washburn is interested in power companies in that part of the country, are you not, Mr. Washburn?

Mr. Washburn. No; I am not.

Secretary Baker. You were at one time?

Mr. Washburn. I was at one time.

Secretary Baker. I knew that at one time Mr. Washburn was quite extensively interested in the power developments there. During this war I had occasion to survey the power situation in the United States. I surveyed that around Niagara Falls, in the Northeast, the Middle Atlantic, the South Atlantic, and some of the Western sections of the country. The power shortage in this country now is very large, and large in every section of the country, so that those companies which by foresight and activity have installed hydroelectric plants anywhere or large central generating stations have practically a monopoly situation in their field of operation. And I am frank to say that the Muscle Shoals dam, to me, is the greatest opportunity that I know of for the Government, in a fair, nonconfiscatory way to control a monopoly situation of the sources of power upon which the industries of the country depend.

Now, if I may turn aside to one other suggestion of Mr. Washburn's: In dealing with Mr. Washburn's figure of $15,000,000 salvage of the plant, which he says he proposes to save by spending $38,000,000 of new capital, my associates have undertaken to figure out what that $15,000,000 part of the plant is. I think it has to be conceded that it is what Mr. Washburn and his associates spent about $38,000,000 in creating down there. So that if Mr. Washburn insists that the part of the plant which we can operate by spending $38,000,000 is worth $15,000,000, then he must concede that he spent $38,000,000 of Government money to produce something worth only $15,000,000.

There is only one other aspect of this matter upon which I want to say a word, and that is the relation of this bill to the Air Nitrates Corporation. I think Mr. Washburn will say to this committee that long before the Government undertook to build a nitrate plant at Muscle Shoals he wanted to build one there; that Mr. Washburn regards it as the most favorable place in the United States, not now occupied, for the building of a cyanamid process nitrate plant; that he was very anxious to have the Muscle Shoals dam built and the power of the Muscle Shoals dam placed at his disposal for the erection, as a private enterprise, of a cyanamid plant at Muscle Shoals. It has been one of his activities for many years to bring that about. I make no comment upon it or characterization of it. He was in that business, and he thought that he could benefit the farmers and himself, too, if he could procure the Government to build the Muscle Shoals dam and sell the power at a very low rate, in order that he might sell cyanamid and its derivatives as a fertilizer.

So that Mr. Washburn until he got the plant there believed that a plant ought to be put there and operated in the interests of the agriculture of this country. Now that the Government has the plant and has a contract with Mr. Washburn by which he has agreed that the Government may operate under his processes, it seems to me Mr. Washburn ought not now to take the view either that that is an improper place or that it is unwise to continue the operation of the plant.

My associates will take up the details of these matters; I am only dealing with the high spots.

Senator KENDRICK. I would like to ask you a question or two here, Mr. Secretary. There is one which it seems to me is of extreme importance in connection with the operation of this plant. As I understand it, the primary purpose that the Government wishes to serve in operating this plant is to perpetuate it and to have it ready and available in case of an emergency?

Secretary BAKER. Yes, sir.

Senator KENDRICK. With that idea in view, will it not be almost necessary to have the plant operated, as against having it stand idle?

Secretary BAKER. For three reasons, Senator: In the first place, it will cost us about $400,000 a year to take care of it standing idle, with all the guarding and the rest of it. That would be perfectly wasted. In the second place, if we operate that plant, this being a new art and in process of development, when you come to rely upon it in a war emergency it will be up to date.

Senator KENDRICK. And is not that the fundamental reason?

Secretary BAKER. It is the fundamental reason for this bill, to continue the development process, both in the interests of agriculture and for military purposes.

The third reason is that no matter how much we may safeguard it from rain, etc., the deterioration is such that if you were to go in and unlock the doors after four or five years and try to use it in an emergency you will find it not worth operating.

Senator **Kendrick**. It is almost certain, as I have attempted to induce witnesses to say—some of them, perhaps, against their will—that the process is in a stage of evolution at this time. That is to say, the whole process is one of evolution, and if you wait, as you stated a moment ago, until the emergency arises you will have an obsolete plant. And then there is another condition that is almost certain to occur in every sort of industry, and that is that the deterioriation is greater when the plant stands in idleness than when it is operated.

Secretary **Baker**. That is true of every machine, from the sewing machine your wife uses to the largest industrial machine in the world. If you lock it up and leave it, it goes to pieces.

The **Chairman**. Is there anything further that any one wishes to ask the Secretary?

Secretary **Baker**. I have nothing further, Senator. I am going to ask you to let my associates continue the hearing.

(Subsequent to the close of the hearing a letter was received from the Secretary of War, which, by order of the chairman, is here printed in full, as follows:)

War Department,
Washington, May 1, 1920.

Hon. Asle J. Gronna,
United States Senate.

My Dear Senator: Various statements have been made before your committee concerning the hydroelectric development now taking place at Muscle Shoals, Ala., on the Tennessee River. In order that you may have the latest and best information available, I am inclosing a statement of the situation just prepared by the Chief of Engineers, who has this matter in charge.

Cordially, yours,

Newton D. Baker,
Secretary of War.

April 17, 1920.

Memorandum for the Secretary of War:
Subject: Data on power to be available at the Wilson Dam.

The following data on the power that will be made available at the Wilson Dam is submitted for your information:

The head to be created by the construction of this dam will vary from about 70 feet at extreme high stages of the river to about 100 feet at extreme low stages, with a normal head of 95 feet throughout the greater portion of the year. The loss in head at the higher stages is due to the fact that the river surface is raised considerably below the dam while the surface of the water above the dam remains at a nearly constant level.

The dam is to be constructed to accommodate 15 generating units, each consisting of a water turbine and generator, with a normal working capacity of 20,000 kilowatts or about 27,000 horsepower each. The initial installation, designed to supply the existing nitrate plant, is to comprise four units, which will give a total power out of 80,000 kilowatts, or 108,000 horsepower. The complete installation of 15 units is intended to furnish 14 operating units and 1 spare unit, with a total output of 280,000 kilowatts, or 375,000 horsepower.

As is the case at all large installations, except such unusually fortunately situated ones as those at Niagara, the minimum flow of the river will not be sufficient to supply the whole of the power machinery that it is propoced to install. Records of flow for the years from 1895 to 1914, inclusive (except 1904, where the records are incomplete), show that the extreme lowest flow of the stream was sufficient to produce 85,000 horsepower (64,000 kilowatts), but in only 6 years of the 19 recorded did the lowest river discharge fall below the quantity necessary to produce the 100,000 horsepower to be provided by the first installation of machinery. The total time during which the flow was less than sufficient to produce this 100,000 horsepower was but 1.3 per cent of the total time. In other words, the power produced by the dam should be amply sufficient to fulfill the demands of the present nitrate plant without any recourse to steam power, except that on an average of one day every two months there would be a slight shortage of power. It is probable, however, that this shortage would not be seriously felt in the manufacturing process.

The development of but the initial 100,000 horsepower, will, however, result in the waste of very large quantities of power in the form of water passing uselessly over the dam. By increasing the installation of the generators to 200,000 kilowatts—that is to say, by putting in 10 units, or 11, with 1 as a spare, and by using the existing steam plant to supplement the hydraulic power at low flow—a power output of 270,000 horsepower can be secured. The steam plant would then have to be operated during periods ranging from one month to seven months in the year, or, on an average, about four months in the year. The total amount of power produced by steam would, however, be but one-quarter of the total power generated.

The remaining four units whose eventual installation is proposed would generate secondary power, which could be used to save coal in other steam plants by replacing the output of these plants during times of abundant water supply in the river. These extra four units could supply power for more than four months on the dryest years, and for more than six months on the average.

The total average quantity of power that the complete installation would supply will amount to 300,000 horsepower.

It is true that a market for the additional power must be found before it can be sold; but it is the history of all power development that such a market will be found. Thus, at Niagara, where for years the power supply was greater than the demand, there is now an acute shortage of power. The difficulties experienced during the war in finding power for war industries can not be soon forgotten. It may therefore be confidently predicted that all the power of the Wilson Dam will eventually be utilized, and the estimated cost of power should fairly be based on the eventual development, and not on the minor development contemplated for the present demands of the nitrate plant. The cost of the dam is the same, irrespective of the amount of power utilized.

The cost of the dam can not be accurately estimated at the present time of fluctuating wages and rapidly changing prices in the material market. No distinct estimate was made in Document 1262, Sixty-fourth Congress, first session, of the installation of the Wilson Dam, but from that report the items entering the cost of construction and installation of the dam and power plant are as follows:

General engineering and office expenses	$2,275,000
Camps, general plant, and railroad connections	2,212,000
Dam No. 2	4,127,000
Lock No. 2	1,064,000
Substructure of power house and tailrace	2,000,000
Flowage damages	350,000
Road changes	30,000
Clearing	76,000
Head gates	135,000
Racks	68,000
Cranes	50,000
Generaling equipment	4,200,000
Cables and wiring	150,000
Total	16,737,000

It is probable that the cost at the present time will vary from 60 per cent to 100 per cent in excess of prices used in preparing the report in 1916. Some items may reach 100 per cent in excess of cost, while others will probably not exceed 60 per cent and some may fall 50 per cent. It is known that the cost of building the dam has been lessened greatly by the fact that the height has been lowered 15 feet, which makes a considerable reduction in mass of concrete involved as well as height of structure. Considerable saving has been affected in overflow damages by this lower level given to the dam and the plans of the lock have been changed so as to make a considerable reduction in cost of that portion of the work.

Under these circumstances it is believed that the total increase in cost may not be more than 75 per cent of the original estimate.

It may be added also that the navigation features of the structure should receive consideration to provide slack water navigation through the stretch of the river which will be rendered navigable by this dam.

By committee Document No. 14, Sixtieth Congress, second session, the estimated cost of locks and dams with substructure installation for power plants, was $18,300,000. It is believed that even low dams with locks involving no feature beyond the creation of navigable depth would for this same stretch of river, cost about $8,000,000. It is, therefore, believed that this sum of $8,000,000 could reasonably be deducted from the figures given above for the construction of the dam, leaving its cost with regard to power installation to be about $21,000,000 at present prices.

Considering, then, the eventual development, the cost of the 375,000 installed horsepower will amount to but $56 per horsepower and the cost of the average power produced will be about $70 per horsepower.

It is understood that a suspension of construction operations during the present era of high prices has been urged in some quarters. Such a procedure would not, however, be in the interest of economy, for the loss to the United States in interrupting construction at this time would amount to a large sum. There has been expended, to the end of March, 1920, $5,668,921.05, and an additional $1,136,358.37 is covered by outstanding contracts and liabilities. The preparatory work has now been completed, cofferdams built, construction bridge practically complete, construction plant assembled, much of the excavation done, and extensive housing facilities for the construction force provided. The pouring of concrete in the dam will be begun as soon as the spring high water subsides, and will be vigorously pressed, with a view to placing the power generators in operation in January, 1922.

A cessation of work at this time would require that the extensive construction plant, housing facilities, etc., be maintained in idleness at a large continuing and useless expense. Despite the expense so incurred, the deterioration of the plant and structures would be great, as most of these are necessarily of such nature as to deteriorate rapidly, even with the best of care. The cofferdams would be entirely lost, and a considerable part of the excavation as well. The intangible but valuable going value of the present well-organized working force would be lost. It is believed that the loss incident to a protracted interruption of work would not be less than $4,000,000, and it is not believed that any advantage in the way of anticipated reduced prices could equal this figure.

In summary, the construction of the Wilson Dam is believed a most worthy project of public improvement, from which large and commensurate returns are to be anticipated, and it is considered that the public interests require its continuous and vigorous prosecution.

LANSING H. BEACH,
Major General, Chief of Engineers.

(Thereupon, at 1 o'clock p. m., the committee adjourned to meet at 10.30 o'clock a. m. to-morrow, Wednesday, April 21, 1920.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

WEDNESDAY, APRIL 21, 1920.

UNITED STATES SENATE,
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D. C.

The committee met in its hearing room in the Senate Office Building at 10.30 o'clock a. m., pursuant to adjournment on yesterday, Senator Asle J. Gronna (chairman) presiding.

The CHAIRMAN. We will resume our hearings. Col. Burns, who do you wish heard first?

Col. BURNS. Mr. Chairman, Mr. Washburn raised the question of the market existing for No. 2 plant in accordance with the scheme of the War Department, and he put emphasis upon the point that a market does not now exist nor will it exist in the future for ammonium sulphate, which we claim can be made there and sold. In order to get an unbiased picture of the situation the Secretary of War has asked Prof. Milton Whitney, Chief of the Bureau of Soils, Department of Agriculture, to testify, so that we would have somebody who is not tied up with the War Department or with the commercial interests of the country.

The CHAIRMAN. Very well, the committee will be glad to hear Prof. Whitney. Please give your name, connection with the department, and residence to the reporter, then you may proceed and make your statement in your own way.

STATEMENT OF PROF. MILTON WHITNEY, SOIL PHYSICIST AND CHIEF OF BUREAU OF SOILS, DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

Mr. WHITNEY. Mr. Chairman and gentlemen of the committee, I have been asked by the Secretary of War to make a statement of the situation in the country in regard to the supply of nitrogen for fertilizer purposes. The Department of Agriculture has for years had under general consideration the fertilizer situation, but since our country went into the European war it has had, under the control act, special care as the fertilizer manufacturers were required to take out licenses. The operation of this matter was turned over by the President to the Secretary of Agriculture, and we have made a very careful study of the situation, particularly in the last two years.

I think you will all remember the startling announcement made by Sir William Crooks, before the British association, about 15 years ago of the nitrogen situation as it presented itself at that time to his mind, and the necessity of getting some method of producing nitrogen that could be used as a fertilizer in order to increase the yields of the crops of the world and prevent the more or less rapid exhaustion of the soil.

The attention of scientists has been directed therefore for a number of years to this point: We have all felt that the increasing use of fertilizers was one of the most important matters of obtaining production along with increasing population. The mere matter of maintenance of soil fertility, that is, the ability of the soil to produce crops, has been settled. We need not worry about that. History has shown us that the soil does not deteriorate finally but maintains a certain yield. With increasing population, with increasing density of the people, however, we have found it absolutely necessary to increase the yield per acre to meet our needs and to provide the present standard of living.

Senator SMITH of South Carolina. Dr. Whitney, you do not mean to say that experience has shown that land does not deteriorate by use from its original capacity to produce? As I understand your statement there you mean that land will not become entirely barren?

Mr. WHITNEY. Yes.

Senator SMITH of South Carolina. But it will deteriorate?

Mr. WHITNEY. Yes; without attention and care.

Senator SMITH of South Carolina. And without some artificial fertilization?

Mr. WHITNEY. Yes, sir; that is one of the things needed. If the world were satisfied with a yield, say, of an average of 12 bushels of wheat to the acre, we could get along; but the world requires a larger crop yield, a larger return for the labor put on the land. So far as we can determine from statistics that are available, the yield of wheat in England, France, and Germany about 300 years ago was about 12 bushels to the acre. Now, long continued experiments with land that originally yielded more than that have shown generally a decline where no fertilizers were used and no special rotation of crops was practiced, these experiments have shown that the yield has declined to about 12 bushels per acre, so that I should say that without care in cultivation, without modern methods of cultivation, without improved live stock and selection of seeds and the use of fertilizers we would get about 15 bushels to the acre. The yield of wheat in England now is about 30 bushels to the acre, and in France about 28 bushels to the acre, and in Germany about the same, brought about by improvements in their methods of cultivation.

Now, gentlemen of the committee, fertilizers are one of the modern means of getting this increase so much desired in productivity. The reliance of this country on fertilizers has been for nitrogen on the Chilean nitrate deposits. There has been a good deal of speculation as to how long those deposits may last. All natural deposits it is conceivable can be exhausted, but that is rather an unimportant question, to my mind. They will last for a long while.

Then we have used the ammonium sulphate that we get from the gas works and from the coking of coal. The introduction of by-product coke ovens has enormously stimulated the production of ammonium sulphate, and we have watched that matter with a good deal of interest and have helped to bring about the saving of nitrogen from coal.

Then we have used the refuse from our slaughterhouses, namely, tankage, dry blood; and then we have depended to a certain extent upon fish scrap; catching fish, some of them not edible, and the fish are used for fertilizer purposes when not edible.

At the beginning of the European war the Secretary of Agriculture asked me to make a statement to him as to the condition in this country in the way of fertilizer materials. I told him that the potash supply would unquestionably be cut off, because our entire supply came from Germany. President Taft had seen the possibility of trouble from being dependent upon one country across the sea for our supply and had asked the Congress, and the Congress had granted an appropriation to make an investigation of the possibility of securing supplies of potash in this country. I told the Secretary that there was the possibility that from a utilization of the kelp plants of the Pacific coast, and the collection of potash from the cement mills, the use of alunite, found in the western mountains, and of certain brines that occur in the West, and other sources of supply, we would probably be able to produce a sufficient amount of potash for our needs.

In regard to phosphoric acid, we have the largest amount of rock phosphate that is known to exist in the world, so we are safe on that.

In regard to nitrogen, we estimated that with the normal importation of nitrate of soda, with the increasing amounts of ammonium sulphate that we could get from the coke ovens that were rapidly being installed, by-product ovens, and from a use of our ammoniates we would be in good condition so far as our nitrogent supply went.

Now, gentlemen of the committee, at that time I was unaware, as was the War Department, I think, for that matter, that ammonia was going to play such an important part in the war. The sale of ammonia, that we had depended on, was taken over by the War Department, and we had a shortage of that. Nitrate of soda also was in great demand by the War Department, but through arrangements made with them we had a sufficient supply to carry us through.

Another change came, however, that we had not foreseen. That is, the use of the organic ammoniates for feeding cattle. One of the first necessities was increased production of meats and of fats. After this country entered the European war the demand for meat and for feedstuffs were so great that the War Industries Board asked me if it would be possible to entirely stop the use of cottonseed meal for fertilizer and have it all used for feeding purposes. I told them it would not be possible unless they could provide a substitute in the fertilizer industry; that that was one of the supplies we counted on for the farmer. As the result of the war, however, the amount of cottonseed meal, of tankage, of dry blood, and of fish scrap that has gone into feeding has far exceeded our wildest idea of what could be possible. And as the result at present these materials are very hard to get; they are very high priced.

The price of ammonia and of organic ammoniates was formerly controlled by the price of nitrogen and nitrate of soda. In the middle of 1919, or after the armistice of signed and things were coming into more normal conditions, the price of nitrogen and of nitrate of soda fell materially, and, as I remember it, in October it was about 25 per cent higher than the prewar prices. Ammonium sulphate came down, but the price of organic ammoniates went up. We called a conference of the producers of the main organic ammoniates, tankage, cottonseed meal, and fish scrap, and asked them why it was that prices had not come down but were still going up. They very coolly replied: We are not interested in fertilizer; we are out of that class; we are selling now not on the basis of ammonia, as we did to the fertilizer people, but are selling on the basis of the protein content, based on the price of the protein that is in these concentrated feeds, and the price of cottonseed meal, although very high for fertilizer, is very low for feeding purposes. Now, gentlemen of the committee, we find that the greater proportion of these organic ammoniates is going into feeding, over which we have no control——

Senator SMITH of South Carolina. Right there, where you speak of the price of nitrate of soda declining: You will remember that this last fall it declined in the retail market, where it affects the farmer, from about $90 a ton to approximately $60 a ton; while cottonseed meal, that has just half of the ammonia content—7 per cent as against 14 per cent and 15 per cent for nitrate of soda—increased in price from about $40 a ton to about $75 a ton. And that is about their relative positions now.

Mr. WHITNEY. Yes; and the reason for that is that they have been going into the feeding market. While we had the power to fix profits, yet we could not act on the organic ammoniates, the price of which was controlled by the feed market without our having control over the prices of feeds. So that no action was taken.

Gentlemen of the committee, it seems therefore that in all of our estimates we have relied upon the continued use of these waste products. The fertilizer business has been the scavenger business in the past. These materials are now going into the feedstuffs; they are leaving the fertilizer market. I called upon the fertilizer manufacturers to submit prices in October, and I had conferences with many of them, and after the prices had been agreed upon and, say, about a month after that time, one of the large manufacturers of fertilizers came and said that changes had taken place within the month that they had not foreseen; that they had planned to use a certain proportion of garbage tankage—and I might explain that garbage tankage is the refuse from the cities, and we had supposed that that waste product would always be available to agriculture for fertilizers, and we had encouraged the collection of garbage from the cities as a source of ammonia for fertilizer—as I have said, a manufacturer of fertilizers, after those prices were fixed, came and told me that two cities that were model garbage tankage cities—standards, as it were—had simply refused to sell; that they had left the fertilizer market and were preparing their garbage now in such a way as to be useful for feeding purposes and were selling the same for its feeding and not for its fertilizer value.

So that, gentlemen of the committee, the whole market for organic ammoniates appears to the Department of Agriculture to be on the verge of being wiped out, because the department feels that the direct use of organic material for feeding animals is more important than the indirect value where you put it on the soil and expect to get increased crops which would be fed to the animals. Therefore we are looking upon it with great complacency; that is, this change. At the same time, as far as the fertilizer situation is concerned, it causes us a good deal of anxiety. Organic ammoniates have been used more in this country than they have abroad. They have been used for two purposes: In the first place, it has been a good conditioner. It is very hard to apply fertilizer without some conditioner. Sulphate of ammonia, nitrate of ammonia, and acid phosphate in the bag are apt to cake, but with organic material, like fish scrap or tankage used in the North and cottonseed meal used in the South, it makes it in good condition and is nice to handle.

Then, again, we have had this theory in the use of mixed fertilizers in this country, unlike the practice in Europe where they apply their fertilizer materials each time separately and give several applications. The theory of fertilzer in this country is that it is a mixture of nitrate nitrogen with sodium nitrate, which is quick and energetic; and then ammonium sulphate, which comes a little bit later, supposedly, and affects the plant as the effects of the nitrate nitrogen are gone; and then the organic ammoniates, which have to undergo bacterial action and decomposition and are supposed to aid the plant at later stages. So that the American practice is based upon the theory that with one application of these three forms of nitrogen, mixed, of course, with acid phosphate and potash, we have a fertilizer that is effective from the germination of the seed up to the time of maturity of the plant, and one application, which the American farmer wants to make, is sufficient for the crop.

Now, that we have to lose the organic ammoniates, it will be a matter of regret to all of us, because we believe, in a general way, in that theory, and also because we do not know what we can use as a conditioner so that the farmer may have the kind of material that he has been accustomed to using.

The question of whether the theory upon which the mixed fertilizer is based is a sound one or not has never been proven in the field of experiment. The facts appear to be, as gathered from the field experiments in this country and in Europe, that nitrogen in the form of nitrate of soda, or in the form of ammonia sulphate, or in the form of organic ammoniates, which are naturally used, is satisfactory and that each form is equally efficient, that one may be substituted for the other. However, in the case of special crops or under special conditions, that is probably not strictly so. A very rapidly maturing vegetable, a crop like tobacco, or other special crops, may have very different requirements, and we believe they have. But in general farm experiments the plots that have been run with nitrate of soda combined with acid phosphate and potash, the plots that have been run with ammonium sulphate combined with acid phosphate and potash, and the plots that have been run with organic ammoniates combined with acid phosphates and nitrate of soda have given approximately the same results. We see no difference.

The fact of the matter is that from the long-time experiments—take those of Rothampstead, England, and the long-time experiments in the Pennsylvania station and at the Ohio station, where experiments have been going on for from 20 to 30 years, and in England for 70 years, we are pretty well satisfied that these three forms of nitrogen are interchangeable. At the same time we think that it is better, that it is safer at least, to have these mixtures; not to reply upon the one or the other form alone. We do not get that from actual experience, but we get it from a fear that the plot experiments that have been carried on are not altogether satisfactory. It is very difficult to draw interpretations from them.

As a matter of fact, in this country the fertilizer practice varies. You can get fertilizers with all three forms of ammonia. You can get fertilizers with nitrate of soda as the only form. You can get fertilizers with sulphate of ammonia as the only form of nitrogen, and all equally satisfactory. The fertilizer men make the claim that this brand is put up in a particular way, and that the brand indicates or carries with it excellency for this particular section or for that particular crop. But so far as we know such claims are not founded upon facts.

Senator SMITH of South Carolina. Right in that connection. Dr. Whitney. I was interested in your statement about the period at which stores of ammonia available for a plant might vary in its effect both as to the beginning effect and the exhaustion thereof. I might state in that connection that from experience of a great many of our farmers with a staple crop, such as corn and cotton, we have found that nitrate of soda is more immediate in its effect, but it is very doubtful whether after the plant begins to stimulate the exhaustion is any sooner than in the case of cottonseed meal, which is 4 or 5 or 6, or perhaps, even 10 days later in its perceptible effect; whether it is any less complete in its effect once the plant begins to assimilate and its exhaustion is later. The same thing is true as to suphate of ammonia. The only thing I have seen is that the soda is more immediate in its effect upon the plant, but once the plant begins to assimilate then it is very doubtful whether or not the exhaustion is any sooner than in any given one.

We have now come to the point of putting the soda under the cotton rather than on as a top dressing. The theory heretofore has been that we would allow the natural fertilizer of the soil, so far as ammonia was concerned, to be depended upon for the germination and the first stages of growth of the plant and then apply nitrate, and we would have the effect of it to maturity, or approximately to maturity. But we have found that by putting just the same amount perhaps as we would have put on of sulphate of ammonia or organic ammonia, that although it does stimulate the plant from the beginning, the question is whether it is any sooner exhausted or not.

Mr. WHITNEY. Yes.

Senator SMITH of South Carolina. Because the amount you put on must be graduated to suit what you want in the development of the plant, and if you put a sufficient amount of nitrate of soda to meet the nitrogenous needs of that plant from germination to maturity we find it very satisfactory.

Mr. WHITNEY. Yes. Of course weather conditions will also affect it.

Senator SMITH of South Carolina. Yes; because rain would tend to leach any form of it?

Mr. WHITNEY. Yes; or a dry condition from the time of application would affect it.

Senator SMITH of South Carolina. Yes.

Mr. WHITNEY. It is not an easy matter. But we do believe in three forms of nitrogen; that they have different effects upon different crops and in different periods of crops, and there is some difference in their effects upon different periods of different crops. Now, gentlemen of the committee, this is a sagnificant fact, that the fertilizer industry of the country has been dependent upon the nitrate supply from Chile, which is a foreign country, and which nitrate supply has to come to us by boats; and then upon waste products. That is, upon the amount of cotton we grow; upon the number of animals we slaughter; upon the number of fish we catch; and upon the amount of pig iron that we make. We can not increase the supply of nitrogen from any of these sources simply because we need more in agriculture, and that for the reason that we do not grow cotton for fertilizer purposes; we do not slaughter animals, or, that is, we do not raise animals for the value of their waste products. That is an insignificant thing in that connection. So that the fertilizer business has been dependent upon waste products, and it has not been possible heretofore to extend the use of fertilizers to the Northern and Central Western States as rapidly as we think would have been wise because we have not had the different materials to make fertilizers from. We therefore feel that the fertilizer industry should have an independent source of producing nitrogen compounds independent of other industrial needs of the country, and so that the amount can be contracted or expanded without influencing other needs of mankind.

Senator RANSDELL. Dr. Whitney, I was not here at the beginning of your testimony, but I am quite much interested to know what you think about fertilizers for corn and cotton in the bottom lands of the Mississippi River, for instance, like my section. I am in the overflow sections of the Mississippi River, as you know, up above the city of Vicksburg, but, of course, on the Louisiana side, on the delta lands or the alluvial soil. As those lands begin to wear out, or to get a little old, and need fertilizer on them, I would like to know your judgment of what would be the best fertilizer for corn and cotton in that region.

Mr. WHITNEY. Senator, the experience of the world, the results of all fertilizer plot tests that have been made, is that mixed fertilizer is better, is safer, than any fertilizer standing alone. That is almost universally shown in the special plot experiments. It is not altogether in accord with the actual practice on farms, and we do believe that there are cases where one or more of these three elements can be left out, but unless we know that the feeling is that a complete fertilizer is safer.

Senator RANSDELL. Just what do you mean by a complete fertilizer?

Mr. WHITNEY. A fertilizer containing nitrogen, phosphoric acid, and potash.

Senator RANSDELL. And potash?

Mr. WHITNEY. Yes, sir; the three elements of fertility. The only thing that I can suggest to you would be that a fertilizer of that kind relatively low in nitrogen and higher in phosphoric acid and with a medium amount of potash would be the fertilizer that would best meet your conditions.

Senator RANSDELL. I have been urged on my own plantation to use nitrate of soda as an ideal fertilizer for corn. I do not know whether to follow that advice or not.

Mr. **Whitney.** I should not think that would give you as good results as if you used less nitrogen on those particular soils and more phosphoric acid with some potash.

Gentlemen of the committee, the world has been for many years considering the possibility of increasing the supply of nitrogen for fertilizer purposes, recognizing that it is one of the greatest factors in increasing crops, and that we must not be dependent, as we have been in the past, upon nitrate of sode imported by vessel from a foreign country; the supply of ammonium sulphate, which is limited by the demands for pig iron and the coking of coal; and the waste products from the slaughterhouses and from the fish that are caught in the sea.

They have, therefore, been working to the end of producing fixed nitrogen for some years. Germany has apparently succeeded in making herself independent of Chilean nitrates by the great strides taken in this fixation problem. The Department of Agriculture has realized the necessity for a work of this kind, and even before the war we put up a Haber machine for studying the fixation of nitrogen. I think it was the first that was put up in this country. We have been working on that problem as far as our means would permit. When the country got into the European war the War Department came to us and asked for cooperation, which we were very glad to give, and we are cooperating with the War Department to-day.

My own feeling has been that the Haber process is the most desirable process. The cyanamid process is well known and has been worked out and is a practical thing, and probably produces ammonia cheaper than by any other method. The Haber process is a much more difficult method; it is one we do not understand, presenting very great mechanical difficulties, but I think in time those difficulties can be overcome and will give us a standard so far as we can see at the present.

To divert a little from the nitrogen problem, I will say that the Department of Agriculture some years ago investigated the phosphate deposits of the country as a source of fertilizer, and we found that the present method of mining phosphate rock was extraordinarily wasteful. Practically all of the rock that is mined—and there are two large deposits that we draw from now, in Florida and Tennessee—mostly all of this rock is mined and mixed with sulphuric acid to convert it into acid phosphate for our fertilizers. And the acid phosphate forms about 60 per cent of the weight of the fertilizers that are used in this country. To mine the rock in order to maintain the standard that is required of acid-phosphate manufacturers in this country, the Bureau of Soils of the Department of Agriculture found that for every ton of phosphorus that was sold from a given mine 2 tons of phosphorus were left on the dump as too impure to go into the acid-phosphate market. It appeared, therefore, that the method of handling our phosphate deposits, which are very large, yet, like all natural deposits, are not absolutely inexhaustible, required some modification. We worked on the problem of extracting phosphoric acid from the rock by methods that would eliminate the use of sulphuric acid, but it would be substantially the same in cost per pound of phosphoric acid extracted.

The first thing we tried was the electric furnace. We put in a mixture of phosphate rock, coke, and sand, and fused it with electrodes and electric current. When this rock was in a molten condition, dense white fumes of phosphoric acid were given off, and, reaction taking place and silicate of lime being formed, the phosphoric acid was set free. Those gases were put through a Cottrell precipitator, and we obtained phosphoric acid in a very pure form. We entered into negotiations with a commercial firm in Hoboken, and made a run of six months, and at the end of that time we found that the cost of the current was so great that the cost of producing phosphoric acid by this method was about three-fourths of a cent more than by the sulphuric-acid method. We felt, therefore, that unless we could get cheap water power the electrical method could not be used. As a matter of fact, our calculations were based upon electric power at $25 per horsepower per year. If you could get electric power for $6 or $10 per horsepower per year, you could use an electric furnace and get phosphoric acid out cheaper than you can by the sulphuric-acid method.

The next step, therefore, in the work of the Department of Agriculture was to use another source of fuel for the electric current, and we turned to fuel oil. We built a furnace on a semicommercial scale, and found that it was necessary to make the rock up into briquets containing phosphate rock, coke, and sand. As we had to add sand to pure rock, and as iron and alumina rather helped this melting than otherwise, we found that we could use the mine run. And we found that this material that had heretofore been thrown on the dumps was actually better material for melting than to use the rock that the sulphuric-acid people were using. So that by using these briquets and melting them in a furnace very similar to an iron furnace a reaction occurred in there. That is made without any binder and is only the material that is left on the dumps; and if necessary and occasionally we add sand to it.

Senator Smith of South Carolina. What is the source of the acid in this composition and in that [pointing to some bottles exhibited by the witness]?

Mr. Whitney. The acid in that is combined with lime in insoluble form. It is dry calcium phosphate. That is usually mixed with sulphuric acid and is in the ammonia calcium phosphate form for acid phosphate. Instead of using sulphuric acid we use sand. We use silica, and at the temperature of fusion the silica drives off all gas and itself enters into combination with the lime, so that we get glass, which is silicate of lime, and from which phosphoric acid has been entirely expelled. Now, we can use mine-run stuff. Therefore, if this method can be perfected on a commercial scale, as we think it can, phosphoric acid can be driven off at the mine, thus saving 2 tons of phosphate rock to every 1 ton that is mined now, and, as we believe, it can be made more cheaply.

We have this phosphoric acid in liquid form [pointing to bottle on exhibit before committee]. It is so concentrated that it is frozen at this temperature and occurs as crystals. At a little higher temperature it would melt. This itself is somewhat difficult to transport; although it is not as corrosive as sulphuric acid, still it is a little bit difficult to transport, and it is impossible in this form to apply it to the soil.

Having obtained our phosphoric acid, we looked around for some way of fixing it so that it could be used as fertilizer, because in this form it could not be so used. Instead of combining that with lime, where there is always the danger of reversion, and the lime itself not being of any commercial value, we conceived the idea of mixing it with ammonia and making ammonium phosphate.

At this point, or after we had fully considered this matter, we went to the War Department and said, "Here we have phosphoric acid, which is not a fertilizer itself in this form, and you have ammonia gas, which is equally useless directly as a fertilizer, so let us combine them." Now, the ammonia gas that is given off by the Haber process, or by the cyanamid process where that is converted into ammonia, gives a gas that in its present form is entirely useless for agriculture. It has to be absorbed and fixed into solid form, generally crystalline form, by absorption. We can absorb that ammonia gas in sulphuric acid and make ammonium sulphate. That is an article of commerce now. We know all about it. We have used it very satisfactorily as a fertilizer. There is one thing about it, of course, and that is that the sulphuric acid is merely a carrier. It has no value itself so far as we know. It is only the ammonia that we pay for; the sulphuric acid is put there just to carry it. The ammonia gas that they produce can be absorbed in hydrochloric acid and you get ammonium chloride, which is also a good fertilizer. It may be absorbed in phosphoric acid and fixed as ammonium phosphate. Now, ammonium phosphate, unlike ammonium sulphate, is a more complete fertilizer. Every part of it carries its own freight. When you are shipping ammonium phosphate you pay freight on the ammonia and on the phosphoric acid. But when the stuff is delivered you are paying per unit of ammonia and per unit of phosphoric acid, so that both of them pays the freight.

In addition to sulphuric acid and hydrochloric acid and phosphoric acid this nitrogen gas can also be absorbed in nitric acid and you get ammonium nitrate. Ammonium nitrate has been used in an experimental way for a great many years and has given satisfaction. It has never been used in a commercial way because its value has been too great. It has never been possible to use it on account of cost of production. But if they can produce ammonia as they appear to be able to do it to-day at Muscle Shoals, or as they are prepared to do it at Muscle Shoals, and if they can fix our phosphoric acid by absorbing some of their ammonium nitrate we get two highly concentrated fertilizer constituents—ammonium nitrate, which has nitrate nitrogen and ammonium nitrogen, and phospate. Every constituent of these two pays its own freight.

In addition to that we need potash, and I have suggested to the fertilizer trade, and have suggested to the War Department, that if they could use some of our phosphoric acid and combine it with potash and get potassium potash, which is quite possible, then they would get all three of these elements in the most concentrated forms that fertilizer can exist in.

Senator Smith of South Carolina. Dr. Whitney, right at this stage let me ask you: Would it be possible in these concentrates to combine the ingredients in their proper balance to their fertilizer relation?

Mr. Whitney. Yes; you can combine them in any proportion that you wish.

Senator SMITH of South Carolina. You know that that is very important for a balanced fertilizer.

Mr. WHITNEY. Well, that is one of the beauties of this—you have the power to mix them in any proportion within very wide limits.

Gentlemen of the committee, I have prepared here samples made of these very materials and made by the very process that we have been discussing—the one that may be used at Muscle Shoals. I have here a fertilizer corresponding to 8–2–2.

Senator SMITH of South Carolina. The ordinary combination and the one used most generally is either 8–2–2 or 8–2–3 or 8–4–4, according as the soil indicates the need thereof?

Mr. WHITNEY. Yes. I have given here the proportions of each of these salts that would be used, and then I have given the composition of the mixed material, which is so concentrated that if you want to dilute it to the ordinary strength, 2–8–2, you have got to use 83 per cent of filler.

Now, the saving of the freight and of car space in the fertilizer movement by the elimination in transit of 83 per cent of the weight of your fertilizer of this grade, 2–8–2, is a very important item.

The next grade is 4–8–4. I show the mixtures and the composition of these mixed salts. And if you want to dilute this one to the strength 8–4–4 fertilizer, you have got to mix 75 per cent of filler.

Senator SMITH of South Carolina. I have the formula here, with 10 per cent of nitrogen, 8 per cent of phosphoric acid, and 4 per cent of potash. Now, in that case to dilute it as fertilizers are ordinarily sold you would have to use 58 per cent of filler.

Mr. WASHBURN. What were those proportions?

Mr. WHITNEY. Ten and eight and four.

Then, Senator Smith, I have a mixture here that contains 4 per cent of nitrogen and 8 per cent of phosphoric acid and 10 per cent of potash. You see there is high potash corresponding to the high nitrogen.

Senator SMITH, of South Carolina. That is just to demonstrate that you can mix them in any proportions that you see fit?

Mr. WHITNEY. Yes, sir. That one would require 69 per cent of filler. That material is completely soluble in water. Ammonium nitrate is a desirable fertilizer constituent but it is limited in its use; it can not be mixed with acid phosphate in any large amount without causing reversion and loss of nitrogen.

Senator SMITH, of South Carolina. It can not be mixed with what?

Mr. WHITNEY. With acid phosphate. You can not use ammonium nitrogen in large proportions. Neither can you use cyanamid in our fertilizers except in small amounts. But in the form of ammonium phosphate you can mix any quantity of ammonium phosphate that you wish without any change. So that in this form [pointing to bottle exhibited before committee] you can make any mixture within a very wide limit and you get the most concentrated form of fertilizer that is possible. This all comes from the possibility of making ammonium nitrate; the possibility of making ammonium phosphate, which is proposed both by the Department of Agriculture, because we have to have some way of utilizing our phosphoric acid that we want to conserve our supplies of; and by the War Department which proposes to make ammonium nitrate, and which can not be used unless they have the form of acid phosphate with which it can be safely mixed. And this is the form in which it will mix [pointing to bottle exhibited before committee].

Senator SMITH, of South Carolina. So you are of opinion that if we can find a source of power that will make the production of phosphoric acid sufficiently cheap so that in place of having sulphate of ammonia, which necessitates transportation and carrying charges on the useless elements, sulphuric acid, that is combined with the ammonia, that you would have the phosphoric acid binder combined with ammonia, and you would have two elements and would only lack one other in order to get a balanced fertilizer?

Mr. WHITNEY. Yes, sir.

Senator SMITH, of South Carolina. If you can combine them with one process.

Mr. WHITNEY. You can, with the potash that you have or the acid phosphate. There are two ways in which that can be combined with potash, and one of them can be carried on right at the mines. In driving off your phosphoric acid from the phosphate rock your object is to introduce silica to displace the phosphoric acid, and thereby instead of having phosphate of lime you have silicate of lime which is thrown away as glass and silica. You have to have enough silica to combine with your lime to displace the phosphoric acid, and in this work we get the conversion of 98 per cent of phosphoric acid or some such figure as that. Instead of using pure sand just as you would take it up from the road it is possible to use shale. You can use potash shales; and there are many of these shales that carry as high as 4 per cent of potash. In using that instead of sand the fusion is not interfered with, the reaction is not materially interfered with, and at that temperature you drive off your potash from your shale, and that combines with the phosphoric acid that is going off at the same time.

We consider—that is, the chemists associated with me consider—that it is not altogether a satisfactory thing from a theoretical point of view. The acid phosphate comes off in a different condition from the potash. You can get the potash off from these rocks just as we are collecting our potash from the cement mills, but the conditions in the furnace are generally different to make a high conversion of potash from phosphoric acid. But it is perfectly possible to bring them both off at the same time, although it may be that neither of them is very completely driven off. That has got to be determined by more elaborate investigations. The possibility, however, is there of getting your potassium phosphate formed at the same time you are forming your phosphoric acid. That would not, however, be a satisfactory form to use. That would give you acid potassium phosphate and the stable salt that we have used here is the dipotassium phosphate. The treatment of any salts of potash, except the sulphates—that is, usually muriate of potash—in connection with this acid liquor would give you diacid phosphate at a slightly elevated temperature then you would have by the use of hydrochloric acid, which is of value and can be sold. So that the possibilities are right there at the phosphate mines if you have the money to make this complete fertilizer right in the same building.

Senator SMITH of South Carolina. So that it is your opinion the plant erected at Muscle Shoals for the production of nitrogen, even in the form of sulphate of ammonia at the present time, is highly desirable for fertilizer purposes now?

Mr. WHITNEY. Surely.

Senator SMITH of South Carolina. There is a market for it all?

Mr. WHITNEY. There is a market for it all. The ammoniates are getting very scarce; they are very high in price; there is not sufficient stuff on hand, and we do not see, especially since the rapid conversion of these organic ammoniates for feeding purposes, I say we do not see how the supply is going to meet the demand, and the time is coming when we must have other means, independent means, of producing nitrogen.

Senator SMITH of South Carolina. Has the production of sulphate of ammonia reached that stage where it is practically no longer experimental?

Mr. WHITNEY. Oh, Yes.

Senator SMITH. Therefore, these plants that are in process of construction now can be used to produce sulphate of ammonia in commercial quantity?

Mr. WHITNEY. Yes, sir; that will be satisfactory. We can use that and we need it.

Now, gentlemen of the committee, this plant is erected. Agriculture needs it. We have been ourselves experimenting with methods for producing these nitrogen products, and for Heaven's sake let us use them. Let us produce the cheapest form of nitrates possible. What is the use of keeping this plant idle when agriculture is in need of the product?

Senator SMITH of South Carolina. I want to ask you one other question, because this matter is so vitally important to the agricultural interests of this country: As you know, and as every practical farmer in the country knows, the one item that is absolutely essential to production, especially of food products, is nitrogen. That is more needed for the growth and development of the plant than possibly any other ingredient, because in our red lands we have more or less potash that is available. In our gray lands we generally get down toward the coastal plain, where we have a source of more or less phosphate. Therefore this being the form in which you now indicate it is possible to combine our nitrogen with our phosphoric acid, leaving out the possibility of combining it with potash, with the Muscle Shoals plant and others that we hope may be erected in the future if this develops—and it must develop, because we have no other source from which to hope to get an adequate supply of nitrogen—that we can utilize all the available phosphate rock through your process by having the affinity of the lime with the silica to displace the phosphoric acid, and then use it as a binder for our nitrogen; I say it is absolutely necessary that the Government shall not relinquish that, but shall carry it on to where it is demonstrated to be a commercial fact.

Mr. WHITNEY. Oh, I think so. Our experiments in the department must be continued. I would not think for a moment of discontinuing the work. This is a vital matter.

Senator SMITH of South Carolina. Do not you look upon it as a fortunate circumstance, if any fortunate thing could come out of this unfortunate war outside of victory over our enemy, that we were compelled to construct at any available water power the plant which is now in process of being directed to keep on for the benefit of agriculture?

Mr. WHITNEY. Yes; I think so. It is realized in Germany that that is one of the real benefits that came to them from the war, that they have a fixed process for nitrogen products.

Senator KENDRICK. If the Government assumes to become a producer of this commercial product—and it is a very essential product, particularly to the agricultural interests—would it be your judgment that the Government ought to exercise discretion as to the price at which it shall place this product on the market and so as not to work hardships on legitimate private enterprise?

Mr. WHITNEY. Well, of course, that is a detail. How far the Government should go into these things is rather a matter of detail. We have a potash-producing plant on the Pacific coast. It is a small concern, with $100,000 of products each year. Of course, $100,000 worth of potash is of no signifiance in the fertilizer industry. But the Government has demonstrated the possibility of utilizing one of the resources of the country. Private enterprise went into the matter but was not willing to take the pains necessary; they went into it for just what they could get out of it. The Government has stuck to the proposition and is getting the products. It is really not important, to my mind, whether we sell the product at one price or at another.

Senator KENDRICK. Not in that small amount?

Mr. WHITNEY. No, sir.

Senator KENDRICK. But when you become a producer on a larger scale it might easily develop that you would upset private industry.

Mr. WHITNEY. Of course, if the Congress in its judgment should say that this production of potash by the Government should be extended, and would give us control of the kelp beds on the Pacific coast, or any other product, it would be important. The product from the Muscle Shoals plant, it does not seem to me, is sufficient to enter to any large extent into that matter. But I am not certain about that. I do not pretend to say anything to you about policy.

Senator KENDRICK. I understand, but my idea is that if the Government exercises such discretion in the naming of a price as would be fair to all that it might very well, on the other hand, prevent the charging of extortionate prices to the farmer.

Mr. WHITNEY. Yes.

Senator KENDRICK. All of which would have a very stabilizing effect upon the commodity and be of great benefit to the farmers of the country?

Mr. WHITNEY. Yes.

Senator SMITH of South Carolina. You are more interested in demonstrating the feasibility of utilizing our resources here than you are in the Government assuming commercial control of it?

Mr. WHITNEY. Yes; I am. I may frankly say that I am. If the Government had no plant it would be a grave question, if you were to ask my advice on the matter, whether the Government should put up the plant. I say, it would be a grave question with me to say whether the Government should put up a potash plant large enough to have a material influence on prices. If there were no such plants the question whether a nitrate plant should be put up now by the Government for agriculture would be a difficult thing to decide. But the Government has done it, for war purposes, and has this plant and we need the product, and it is going right along the line that the country and the world has been working over, and I say we should go at it, and that the price at which these products should be sold is a relatively unimportant matter.

Senator SMITH of South Carolina. You will remember that the original bill authorizing the construction of these air fixation plants provided that their primary object was for war needs, to meet the ultimate requirements of this country for war needs. Then, in time of peace rather than let the machinery lie idle I say what would be a surplus for the country, not being at war, should be used for agricultural purpose; that it seems to me it is a wise thing to do. You have the process——

Mr. WHITNEY (interposing). And agriculture needs the products.

Senator SMITH of South Carolina. You have the plant constructed along the lines of making munitions for the Government in case of war?

Mr. WHITNEY. Yes, sir.

Senator SMITH of South Carolina. During time of peace no such thing being needed by the Ordnance Department and as agriculture is preeminently in need of it, why not use it? That is the situation we are confronted with now.

Mr. WHITNEY. Yes, sir.

Senator KENDRICK. The principal objection, as I understand it, that has been raised to the Government becoming a producer in the open market is the disastrous effects it might have upon legitimate trade in fertilizers. That is to say, that if the Government through any unfair methods might upset the market it would have a disastrous effect upon trade. The question I am asking is to determine if it might not prove under discreet management a very strong stabilizing influence upon the market; that it might sell the product at a price that would protect all other legitimate dealers. It might also prevent dealers from exacting extortionate prices from the farmer.

Mr. WHITNEY. Yes, sir.

Senator SMITH of South Carolina. I think Prof. Whitney will agree with me thoroughly that the hope of adequate production upon the farm is dependent more perhaps, certainly in certain sections of the country, upon an adequate and cheap supply of proper fertilizers than any other one thing that confronts us to-day. You take the advent of a certain pest in our cotton production, and the only hope we have even of making a partial crop is to so highly fertilize that crop with some quick diffusible stimulant that it will cause the plant to grow vigorously and make the crop grow before the development of the pest. On the other hand, in the cereal production, on the thin sandy lands of the coastal plain, it has been demonstrated beyond any question that the use of a concentrated and quickly assimilable form of nitrogen has revolutionized corn production throughout that entire plain. And if this country wants to reduce the high cost of living its first duty is to do two things: Not only to reduce the high cost of fertilizers but to increase the supply, because none of us may hope to ever abrogate the law of supply and demand. If fertilizers that are absolutely essential are scarce they are going to be high, and the products that they will produce are going to be high, and the consequence is that the American people may not hope to adequately supply their needs; that is, that the American farmer can not hope to adequately supply the needs of 110,000,000 to 120,000,000 American people. But with a supply of fertilizer being developed through other channels the price should be reduced.

On the other hand, with the constituents of fertilizer being diverted to other channels and the supply of fertilizer being so reduced that the farmer will have to pay an enormous price in order to get what he needs to produce a reasonable crop on anything like living wages, you can just depend upon it that the farmer is not going to do it. It would be suicidal to expect him to do it. You can take 1 acre of land and with proper fertilizer and the same cultivation that you would give to an acre of land without fertilizer and you would produce twice as much. In other words, with one-half of the acreage planted in America in that section where fertilizer is available and is used properly and the land fertilized and brought to its highest state of cultivation through the presence of the proper ingredients to produce crops you will produce more than you will on all the acreage unfertilized. So I tell you the thing for the American people to do is to be thoroughly aroused to what we need, and that is an adequate and comparatively cheap source of fertilizer for our agricultural lands.

Mr. WHITNEY. Yes; and we could do it in increasing quantities, Senator. The increase in population has been a measure of estimating the efficiency of crop yields. But the increase in the use of fertilizers is going to be for a time greater than the increase in population, because there is so much country that has not taken up the practice.

Senator SMITH of South Carolina. Yes; and any process of reasoning would lead you to know that every wheat crop cut off of our rich alluvial plain has carried away never to be returned, unless you put it back artificially a certain amount of ingredients in the soil that were converted or transformed into the wheat. So that it is only a question of time until this whole country will have to have some sort of artificial fertilizing, either through rotation of crops or by an artificial fertilizer, and that raises this question that it seems to me the public ought to be more familiar with than they are: We hear a great deal about rotation of crops. When you rotate you must rotate with those crops that are rich in nitrogen. They are the clovers and legumes. They do not produce the food crop directly, but indirectly, as you said a moment ago about taking cottonseed meal and putting it on the soil and raising corn and then feeding the corn to an animal; but you would feed the meal to the animal now, because it is the more direct route. When I think of the abandoned millions of acres not producing wheat and rye and corn in order that I may get my money for the year's planting, I can see and you can see how much has been subtracted that is needed. We must find some artificial source by which every acre available for wheat and cereals and textiles can be planted and fertilized without spending a year rotating crops.

Mr. WHITNEY. Yes, sir.

Senator KENDRICK. The primary purpose of operating this plant at Muscle Shoals is for emergency purposes, that we may have it in time of need. With that understanding if you were going to conserve it to the best advantage what method would you adopt? Would you allow the plant to stand still or would you operate it in the meantime?

Mr. WHITNEY. Oh, I would use it.

Senator KENDRICK. If the plant were operated isn't it more likely that at the time of an emergency, whenever it might arise, either at an imminent time or a remote period, that we would have a very much more efficient plant under a plan of operation than we would have if we allowed it to stand idle?

Mr. WHITNEY. I would say so, but of course that is a matter for the engineers to advise you on. I would not attempt to advise you technically on that point.

Gen. WILLIAMS. There is no question about that, I will say.

Senator KENDRICK. I have asked other witnesses that. The important thing would be to have the plant in case of emergency and to have the most highly efficient plant that could be secured?

Mr. WHITNEY. Yes, sir.

Senator KENDRICK. Now, if we were operating it it stands to reason according to my judgment that we would have an up-to-date plant. But if we allowed it to stand still and simply conserved it we might have a plant in fairly good shape as it is to-day but it might also occur that it would become entirely obsolete.

Gen. WILLIAMS. Yes; in 10 years you would have to rebuild it, as it would be likely to get out of repair.

Mr. WHITNEY. The plant itself would deteriorate if standing.

Senator KENDRICK. Almost the same as if operating?

Mr. WHITNEY. Yes, sir. And you would not get the experience in that way that you would in operation. And you would not be keeping up the improvements, and you would not be getting the products that would come from operation.

Gen. WILLIAMS. Another thing, a going concern is very much more valuable than a plant in a stand-by condition. If it is in a stand-by condition and you want to put it into operation the first thing you must do is to gather your personnel, and you must go over the plant and put it in repair, everything that is out of condition, and some parts of it may have to be rebuilt.

Senator SMITH of South Carolina. I have refrained from injecting the question of the Government's activity in language that might seem to look upon it as a purely commercial matter. But I am going now to put it in as strong language as I know how. It appears to me it would be criminal on the part of those charged with the responsibility of agricultural development if they did not insist that the possibilities involved in the very points that you have brought out here should be carried to a successful conclusion; if they did not insist that the Government shall go ahead to the ultimate possible limit of its resources in developing and proving the feasibility not only of an adequate supply of this product from the sources now indicated but as to protecting the price of it.

Mr. WHITNEY. I think you are right.

Senator SMITH of South Carolina. Because fundamentally the whole Government rests upon bread and meat. You have to have biscuit before you can use bullets.

Mr. WHITNEY. Yes, sir. And I want to say, Senator Kendrick, that the Department of Agriculture, as I have attempted to show you, is vitally interested not only in the method but in the operation of a plant of this kind. It comes right into and supplies a need which we have felt in the Department of Agriculture must be supplied, and we would look with great and grave concern upon any proposition to keep idle any plant that could help in the development of American agriculture, to keep it idle just because it happened to belong to the Government.

Senator RANSDELL. Would the operation in a proper and businesslike way of this plant and the development and sale by the Government of the normally expected product of the plant seriously interfere with any legitimate private enterprise at all in the country?

Mr. WHITNEY. In my judgment it would not.

Senator RANSDELL. Would not it rather be helpful instead of hurtful to legitimate enterprise if this plant should be conducted on a strictly business basis?

Mr. WHITNEY. I think it would.

Senator KENDRICK. There is a question that goes to the point I was trying to bring out a while ago: Assuming that our primary purpose is to conserve this plant for future emergencies, isn't it true that our best way to accomplish that purpose is to keep the plant going?

Mr. WHITNEY. Absolutely.

Senator KENDRICK. Wouldn't it be highly profitable to the Government under such conditions to have it operated in case it would do just this thing—that it would pay all expenses and pay for all improvements from time to time that might be found necessary to keep it entirely up to date, and any other income that might be necessary; wouldn't it be highly profitable to keep it going?

Mr. WHITNEY. I think it would. In my judgment it would.

Col. BURNS. Along that line, may I inject something here?

Senator RANSDELL. Certainly.

Col. BURNS. The question has been raised about keeping that Muscle Shoals plant in a stand-by condition, and Mr. Washburn has very emphatically stated that if it is kept in a stand-by condition it would not deteriorate. I would like to read what he said before the Committee on Military Affairs, House of Representatives, February 11–28, 1916, page 9:

> The staff that would steadily be employed in this plant would be 10 per cent to 15 per cent of the number that would be required in the event of war for its full operation. Chemical plants of this kind require a trained body of men, and in the event of war threatening the country we should have the almost insuperable difficulty of training from green hands substantially 90 per cent of the requisite directing and working force. It is fairly a matter of grave doubt whether, under the unsettled conditions and excitement of approaching war, and the exigent demands on everyone connected with the Army and the Navy, such a plant could be placed in full stride in less than a year. It may be conceivable that a plant of this sort could be maintained in idleness without such degree of deterioration as to render it useless, but it is highly improbable that it would be so maintained, and a country which should rely for its powder supply upon practically the indefinite maintenance in working order of an idle plant composed of highly delicate and complicated appliances, would be taking a most extraordinary risk which, if it could be avoided,

would be wholly unwarranted. A minor objection would be the cost of maintaining such a plant in readiness for operation, its upkeep, and the interest on the idle capital.

Senator KENDRICK (presiding). The chairman, who has had to leave the room for a moment to answer the phone, requests that I make the announcement that the members of the committee must now take a recess in order to go over on the Senate floor to answer to a roll call. The committee will reassemble at 2.30 o'clock p. m.

(Whereupon, at 12.15 o'clock p. m., the committee recessed until 2.30 o'clock p. m.)

AFTER RECESS.

The committee reconvened, pursuant to the taking of recess, at 2.30 o'clock p. m.

Col. BURNS. Mr. Chairman, Prof. Whitney was dealing this morning with the market for the products of the No. 2 plant. Maj. Gaillard has worked up studies of supply and demand and is familiar with that general question, and we would like to have him speak on that.

The CHAIRMAN. Maj. Gaillard, we will be very glad to hear you.

STATEMENT OF MAJ. D. P. GAILLARD, ORDNANCE DEPARTMENT, UNITED STATES ARMY.

Maj. GAILLARD. The first thing I would like to read is a letter from Dr. J. G. Lipman, Director of the State of New Jersey Agricultural Experiment Station. Dr. Lipman went abroad last summer to investigate this question of the use in agriculture of the products of nitrate plant No. 2, and traveled very extensively all over Europe investigating agricultural possibilities at the same time that Col. Joyes, Dr. Lamb, and other members of the Fixed Nitrogen Commission were investigating manufacturing possibilities.

After Mr. Washburn had testified that the market does not exist in this country for additional quantities of ammonium sulphate, and that ammonium sulphate can not be expected to take the place in fertilizer of Chilean nitrate, the Nitrate Division wrote to Dr. Lipman, and this is his reply:

STATE OF NEW JERSEY,
AGRICULTURAL EXPERIMENT STATION,
New Brunswick, N. J., April 12, 1920.

Col. J. H. BURNS,
Nitrate Division, Office of Chief of Ordnance,
War Department, Washington, D. C.

DEAR COL. BURNS: Mr. Washburn is clearly in error in his statement that "the market does not exist for additional ammonium sulphate in the United States," and that "ammonium sulphate can not be expected to take the place of fertilizer of the nitrogen which is at present being obtained from sodium nitrate."

The market for ammonium sulphate in the United States is certain to expand very rapidly in the next decade. At present there is a striking underconsumption of nitrogenous fertilizer, as pointed out in my report to the Nitrate Division. The same matter was referred to by me in my address before the American Society of Agronomy in December, 1919. A printed copy of this address is being sent to you. With the existing costs of labor, much stress will be put on the need for increasing yields per acre in order that the unit cost of food commodities may be reduced.

The second argument of Mr. Washburn, that ammonium sulphate can not take the place of sodium nitrate, is also based on false premises. Farmers in England and on the continent of Europe whom I interviewed last summer expressed to me time and again the conviction that ammonium sulphate is as satisfactory as sodium nitrate for cereals and for potatoes. In fact, the potato growers in Europe prefer ammonium sulphate to sodium nitrate as a source of nitrogen. These two fertilizers are interchangeable, when due allowance is made for the fact that the efficiency of ammonium nitrogen is somewhat less than that of nitrate nitrogen.

I am sending you several leaflets published by the Board of Agriculture and Fisheries of England, now the Ministry of Agriculture of the United Kingdom. The titles of these pamphlets are: " Storage of sulphate of ammonia on farms;" "The purchase of artificial manures;" "Fertilizers for farm crops in 1918;" "Potato growing;" "Wheat growing." These leaflets will serve to show you that farmers of the United Kingdom are advised to use sulphate of ammonia since it has given satisfactory results.

I am also sending you a copy of a paper by Prof. James Hendrick, of the University of Aberdeen, in which he shows the growth in the production and consumption of ammonium sulphate in European agriculture. Similarly, I am sending you a report from the syndicate in the Province of Loire-et-Chere. You will note that the consumption of sulphate of ammonia in 1918 by the members of the syndicate—the largest in France—was much greater than that of sodium nitrate.

I could send you a number of other pamphlets, but I am sure these will serve to illustrate my point. Kindly return these to me at your convenience. These are the only copies I have.

May I add in conclusion that the need for nitrogenous fertilizers will become more apparent in the near future and that the changed conditions in the labor and commodities market, as well as the changed condition of our transportation systems, will compel us to use much more nitrogen per acre than we are now using in order that human and animal food may still be produced at a reasonable cost? The opposition of Mr. Washburn and others to the operation of the plant at Musce Shoals is based on obvious reasons. The commercial interests in the United States very much object to the introduction of a competitive factor that would serve to lower the cost of combined nitrogen to the farmers in the United States.

Very sincerely, yours,

JACOB LIPMAN,
Dean and Director.

So much for the opinion of a man that is certainly qualified to speak with authority.

Mr. Washburn spoke of a law of limiting factors and said that in the manufacture of fertilizers if they increased one kind of plant food the other kinds must be increased proportionately. That is probably desirable if you can get the other kinds. But with cottonseed meal and tankage going to a large extent out of the fertilizer market probably in two or three years we will not have half as much organic nitrogen as we had a few years ago; and, according to Mr. Washburn's method of reasoning, we should only be able to use half as much fertilizer if we had to stick to these hard and fast proportions of the past—proportions that, by the way, have been steadily changing during the last 20 years. And if we must use in the future the same proportions of cottonseed meal as we have used in the past, as Mr. Washburn apparently argues, if we find we can not get the cottonseed meal then we can not use but half as much sulphate or half as much Chilean nitrate—which I believe you will agree is an absurd conclusion.

Opposite page 91 of these hearings there is a curve showing the relative prices of Chilean nitrate and sulphate of ammonia reduced to a common nitrogen content. This chart shows very clearly, I think, the fact that the two materials sell on a competitive basis;

part of the time nitrate is slightly more expensive and part of the time sulphate is slightly more expensive. It is a very singular coincidence, if those materials are in no sense substitutes for each other, as Mr. Washburn claims, that they sell on a competitive price basis. The variations in the prices of all of the fertilizer materials, of course, show some similarity on account of the general trend of commodity prices, but by no means the striking similarity that is shown between those two materials.

Further, it is interesting to see what is actually happening in the relative uses of sulphate and nitrate in fertilizer. The figures of the United States census as to the relative use of materials used in mixed fertilizers show that in 1899 in mixed fertilizers sulphate of ammonia supplied one-fourth as much nitrogen as nitrate of soda did; in 1904, one-third as much; in 1909, practically the same quantity; and in 1914 about one and a quarter times as much. Whether those figures are exactly right or not, that certainly indicates the tendency, from 1899, where sulphate supplied a quarter as much as Chilean nitrate, to 1914, where it supplied one and a quarter times as much. Why Mr. Washburn should say at this particular time that the change in the proportions of these two materials must come to a stop and not go further I can not quite see.

Also, the report of the Federal Trade Commission on the fertilizer industry gives the different fertilizer materials used by the larger fertilizer-mixing companies, and there is a very wide range there in the practice of the different companies as to the proportions they use of nitrate of soda and sulphate of ammonia. For instance, the International Agricultural Corporation reports that in their mixed goods they use only one-third as much sulphate as of nitrate. The Armour Fertilizer Works use practically equal tonnages of the two materials, as does the Virginia-Carolina Chemical Co. The American Agricultural Chemical Co. use about one and three-quarters as much sulphate as of nitrate. Other companies used from two to five times as much sulphate as of nitrate, and one company used twelve and one-half times as much sulphate as nitrate.

These wide differences can not be accounted for by the fact that these companies are making different mixtures to supply the peculiar requirements of different localities, because to a large extent they cover the same territory, and some of those in that list are certainly national in their character. This difference is accounted for partly by the customs of the particular company, and principally by the fact that they buy whichever material seems the best purchase under the market conditions. It is a question of which they can get and the price at which they can get it.

So much for the question whether ammonia nitrogen can take the place of nitrate nitrogen in fertilizer. We have not assumed that ammonia nitrogen would completely replace nitrate nitrogen in fertilizers; we have assumed that the increased demand for nitrogen will be supplied largely in the form of ammonia nitrogen, and that by 1930 there will be not far from the same amount of nitrate nitrogen used for fertilizer as there is to-day.

The CHAIRMAN. In other words, you do not regard this as a competitor against the sulphate of ammonia?

Maj. GAILLARD. Against the Chilean nitrate?

The CHAIRMAN. No; against what we get from the coke ovens.

Maj. GAILLARD. No, sir; we do not, in the sense that we think there is a big enough demand to use all of the sulphate of ammonia produced.

The CHAIRMAN. There will be a market for all that the Government can manufacture and also all that can be supplied from the coke ovens?

Maj. GAILLARD. Yes, sir. We do not want to see the coke ovens go out of business; they are very important to the military preparedness of the country. Moreover they are a conservation measure. During the war the Ordnance Department did everything it could to encourage the building of coke ovens, and it would not deliberately turn around and do something now that it thought was going to put them out of business.

Mr. Washburn showed you a chart setting forth his ideas as to future consumption and supply of nitrogen, and drawing a sharp distinction between ammonia nitrogen and nitrate nitrogen. This chart showed that in 1930, if I remember the figures correctly, about 1,000,000 long tons of Chilean nitrate would be the demands for nitrate nitrogen. Then he showed a surplus of ammonia. Of course, if that ammonia can take the place of the nitrate there is no surplus, as simply that much less Chilean nitrate will be imported. Plant No. 2 will fix nitrogen equivalent to about 250,000 tons of Chilean nitrate, and if operated will cause the imports of Chilean nitrate to be reduced still further. But even then we must import Chilean nitrate to meet the deficiency in the domestic supply of nitrogen.

Mr. Washburn also stated that the capacity of the by-product coke ovens now built and building was 625,000 tons of sulphate of ammonia. I would like to read from a recent bulletin of the Geological Survey, which follows this matter and is supposed to be informed on it and has collected statistics on the total production of coke and the total production of sulphate of ammonia for many years past. This bulletin is entitled "The Coke Industry in 1919."

Senator RANSDELL. What is the date?

Maj. GAILLARD. It is not dated, sir, but was issued within the last two months. At the end of this report they say:

> If the figures showing the recovery of the by-products per ton are multiplied by the number of tons given above as the annual coke capacity of the ovens now built and building in the United States, namely, 36,800,000 tons—a moderate estimate assuming 85 per cent operation—the annual capacity for the recovery of by-products by the end of 1920 will become 977,100,000 pounds of ammonium sulphate.

That is 487,000 tons. Mr. Washburn added in 55,000 tons from gas works, and we take no exception to that figure. That added in gives the Geological Survey estimate of capacity at the end of this year about 15 per cent lower than what Mr. Washburn says is now the capacity. That is not a great deal of difference; it does make a difference, however, of about 80,000 tons of sulphate, which is what we propose to make initially at plant No. 2.

Senator KENDRICK. Just a moment. That would increase the total?

Maj. GAILLARD. His figures are higher than the Geological Survey's figures.

Senator KENDRICK. His figures of consumption?

Maj. GAILLARD. No; of production.

Senator **Kendrick**. How much higher?

Maj. **Gaillard**. About 15 per cent, or about 80,000 tons.

Senator **Kendrick**. Which difference might easily be absorbed by the increased demand for the product?

Maj. **Gaillard**. Yes, sir. But the point I was making is that it is a very high estimate of the present capacity of the coke ovens.

Senator **Kendrick**. But even allowing his figures as correct, the difference would be easily absorbed, it would seem, by the increased consumption?

Maj. **Gaillard**. Yes, sir. If the manufacturers of sulphate thought there was going to be any great overproduction of sulphate in this country they would not be making contracts for next year at a price that is higher than the price this year. If the supply were increasing relatively to the demand, prices would be coming down instead of going up.

When it comes to an estimate of the total quantity of nitrogen required, it is merely a question of one estimate against another. Mr. Washburn estimates the total nitrogen consumption in 1930 at 345,000 tons. It is interesting to note that in the 10 years from 1900 to 1910, the use of nitrogen in the United States increased by nearly 250 per cent, and in the 10 years from 1905 to 1915, by 180 per cent. According to Mr. Washburn's figure of 345,000 tons he shows an increased use of nitrogen in the 15 years from 1915 to 1930, of only 73 per cent, whereas in two preceding 10-year periods it increased in one period by 250 per cent, and in another by 180 per cent. And yet he says that in 15 years it is only going to increase 73 per cent. That is in spite of the world experience that, broadly speaking, the use of nitrogen doubles every 10 years. The experience of this country in the 15 years prior to the war showed that the use of nitrogen increased about fivefold. While estimates as to future consumption are necessarily a matter of opinion, I believe it will be evident that Mr. Washburn's estimates as to nitrogen consumption in 1930 are very conservative. Of course, we can not tell until 1930 which is right.

Senator **Ransdell**. Judging the future by the past, however, you feel sure it will be very much larger than Mr. Washburn computes?

Maj. **Gaillard**. Yes, sir; because every factor that tended to increase the use of nitrogen in the past is continuing now and to an increased extent.

Senator **Ransdell**. You think there is a tendency now to do better farming than there was in the past?

Maj. **Gaillard**. Yes, sir; and the demand for fertilizer should increase very considerably with the present high price of labor and the high price of lands. Of course, the prices have been going up right along, but there has been this big jump in the last three years.

Senator **Smith** of South Carolina. About what was the beginning in this country of the use of commercial fertilizer?

Maj. **Gaillard**. I think it was in the seventies or eighties.

Senator **Smith** of South Carolina. It must have been about that time, about the time that they began to exploit the Peruvian Islands and get what was known as the Peruvian guano. The Government offered certain concessions off the coast of Central and South America.

There was an act passed here in Congress that anyone discovering any of these islands would have the support of the Army and Navy to maintain ownership and control—under the United States, of course—of that island for the fertilizer that he might get from it. And I believe the act went far enough to protect him in the prices for the different grades, according to the leaching. Until the exhaustion of that supply that was the fertilizer that was commonly sold on the market. Then, of course, chemists got busy and found out what was the really valuable content of this material which had such wonderful results when applied to the soil. I think the use of artificial fertilizers in this country began with the production of the guano deposits from the Peruvian Islands, and there has been a rapidly increasing use. The fact is, however, there are but two things that limit the widespread and intensified use of artificial fertilizer, and that is the price and the available supply. That is all that is going to limit the use of nitrogen combined with those other elements in this country.

Senator **RANSDELL.** Do you know the present price of Chilean nitrate?

Maj. **GAILLARD.** About $80 a short ton.

Senator **RANSDELL.** That is, 2,000 pounds?

Maj. **GAILLARD.** Yes, sir.

Senator **SMITH** of South Carolina. I think you are a little wrong; about $5 a ton. I am having it hauled to my farms now for $75 a ton.

Senator **KENDRICK.** Anyway, your estimate is safe.

Maj. **GAILLARD.** Yes, sir.

The **CHAIRMAN.** Does that bulletin of the Geological Survey from which you just read quote the prices of the by-product of coke?

Maj. **GAILLARD.** No, sir; it simply gives the quantities produced. It contains a discussion of the by-product coke oven situation in 1919, a list of the new ovens constructed, production by States, etc.

The **CHAIRMAN.** Would you care to insert that in the record?

Maj. **GAILLARD.** Yes, sir; I believe it would be very valuable.

(The bulletin referred to as here printed in full, as follows:)

THE COKE INDUSTRY IN 1919.

PRODUCTION DECREASED BUT CAPACITY OF BY-PRODUCT OVENS INCREASED.

The outstanding features of the coke industry during the year 1919 were the great slump in demand that followed the armistice and a remarkable increase in the proportion of by-product coke made as compared with beehive coke. According to preliminary estimates made by F. T. Tryon, of the United States Geological Survey, Department of the Interior, the total production of coke in 1919, including beehive and by-product but excluding gas-house coke, was 44,821,000 net tons, a decrease as compared with 1918 of 11,657,000 tons, or 20.6 per cent. The decrease was confined almost entirely to beehive coke, the production of which fell off 36 per cent. The output of by-product coke decreased only 3.2 per cent. The output of by-product coke consequently exceeded that of beehive coke for the first time. In 1918 about 46 per cent of the total coke made in the United States was produced in by-product ovens and 54 per cent in beehive ovens. In 1919 the proportions were reversed, 56 per cent coming from by-product and only 44 per cent from beehive ovens. The year 1919 thus marked a turning point in the history of coke manufacture in the United States.

The quantity of coke manufactured in 1919 at illuminating-gas plants, not included in the figures given above, was about 3,200,000 tons. The total quantity of coke produced in 1919 was therefore about 48,000,000 tons.

These figures are preliminary only. Those for beehive coke are estimated from shipments by rail. Those for by-product coke are based on reports collected from producers in a preliminary canvass. The figures for both are subject to revision and will be revised when the annual statistical canvass is completed.

BEEHIVE COKE.

The blast furnaces are the great customers of the coke industry. In 1918, according to the statistical report of the American Iron and Steel Institute for 1918, they consumed 45,704,000 net tons of coke, or 81 per cent of the total output of beehive and by-product coke combined. In 1919 the production of pig iron fell off 22 per cent and the demand for coke declined in proportion. The reaction was especially felt by the producers of beehive coke. With the growth in the output of by-product coke the beehive coke industry is likely to become more and more an auxiliary source of supply, carrying the peak load in times of extreme activity and correspondingly restricted in times of depression. The fact makes the current output of beehive coke a highly sensitive business barometer.

Table 1 shows in parallel columns the monthly output of pig iron and of beehive coke in 1919. The postwar slump in the demand for both began to be seriously felt about March 15. The low point for the year was reached in May. Thereafter production slowly recovered, only to be further interrupted by the steel workers' strike, which began September 22, and the coal strike of November 1 to December 10.

TABLE 1.—*Estimated monthly production of beehive coke and of pig iron in the United States in 1919.*

Month.	Beehive coke.	Pig iron.[1]
	Net tons.	*Gross tons.*
Monthly average, 1918	2,540,000	3,255,000
January	2,384,000	3,306,000
February	1,787,000	2,948,000
March	2,091,000	3,088,000
April	1,343,000	2,474,000
May	1,103,000	2,108,000
June	1,148,000	2,114,000
July	1,482,000	2,424,000
August	1,699,000	2,742,000
September	1,755,000	2,481,000
October	1,521,000	1,864,000
November	1,647,000	2,407,000
December	1,690,000	2,630,000
Total	19,650,000	30,586,000

[1] Figures for 1918 quoted from American Iron Steel Institute; those for 1919 from Iron Trade Review.

As a result the production of beehive coke fell off 10,831,000 tons, or 36 per cent, from 1918 to 1919. The total output in 1919 is estimated at 19,650,000 net tons (Table 2). All districts shared in the decrease. The production in Pennsylvania and Ohio is placed at 14,861,000 tons, as compared with 22,276,000 tons the year before.

TABLE 2.—*Estimated production of beehive coke, by groups of States, in 1919, with comparative figures for 1918.*

[Net tons.]

	1918[1]	1919[2]
Pennsylvania and Ohio	22,276,000	14,861,000
West Virginia	2,717,000	1,061,000
Alabama, Tennessee, and Georgia	2,042,000	1,695,000
Virginia and Kentucky	1,535,000	1,201,000
Colorado, Oklahoma, and New Mexico	1,401,000	558,000
Washington and Utah	510,000	274,000
United States	30,481,000	19,650,000

[1] Final figures.

[2] Estimates.

BY-PRODUCT COKE.

The total output of coke produced in by-product ovens in 1919 was 25,171,000 net tons, a decrease as compared with 1918 of 827,000 tons, or 3.2 per cent. The effect of the decline in demand for by-product coke upon production was largely counteracted by the completion of new plants. The rate of production was higher during January, February, and March than during the remainder of the year.

TABLE 3.—*Rate of production of by-product coke per 30-day month in 1919.*

	Net tons.
First quarter	2,260,000
Last three quarters	2,043,000
Year	2,098,000

The dull season in the steel industry was most pronounced from April to July. During the last quarter of the year the by-product coke industry suffered from the combined effects of the steel strike, which restricted the demand, and of the coal strike, which curtailed the supply of coal.

The output by States is given in Table 4. The figures show a general decrease as compared with 1918, which affected all States except New Jersey, Ohio, and Pennsylvania. The producers in Ohio reported an increase of 4 per cent. A larger increase (16 per cent) was made in New Jersey, and the largest of all in Pennsylvania, where the completion of new ovens caused an increase of 25 per cent.

In order of rank Pennsylvania came first, with 5,747,000 tons; Ohio second, with 5,445,000 tons; and Indiana third, with 3,691,000 tons. Pennsylvania has thus regained the first place as a producer of by-product coke, a position held by that State from 1915 to 1917, but lost to Ohio in 1918. Pennsylvania is now supreme in the coke industry. It is not only the largest producer of both beehive and by-product coke, but it supplies much of the coal consumed by by-product ovens in other States.

TABLE 4.—*By-product coke produced in 1918 and 1919, by States, with increase or decrease.*

[Net tons.]

State.	1918		1919		Increase (+) or decrease (−).	
	Ovens.	Tonnage produced.	Ovens.	Tonnage produced.	Tons.	Per cent.
Alabama	847	2,634,451	906	2,255,000	− 380,000	−14
Colorado	120	(1)	120	(1)	(1)	(1)
Illinois	626	2,285,610	714	1,705,000	− 581,000	−25
Indiana	1,026	3,898,215	1,216	3,691,000	− 207,000	− 5
Kentucky	108	517,749	108	408,000	− 110,000	−21
Maryland	180	474,368	360	356,000	− 118,000	−25
Massachusetts	400	556,397	400	393,000	− 163,000	−29
Michigan	269	(1)	389	(1)	(1)	(1)
Minnesota	220	784,065	220	586,000	− 198,000	−25
Missouri	56	(1)	56	(1)	(1)	(1)
New Jersey	260	682,148	315	789,000	+ 107,000	+16
New York	615	1,069,587	591	751,000	− 319,000	−30
Ohio	1,658	5,226,334	1,608	5,445,000	+ 219,000	+ 4
Pennsylvania	2,368	4,586,981	2,846	5,747,000	+1,160,000	+25
Rhode Island	....	....	40	(1)	(1)	(1)
Tennessee	24	124,469	24	105,000	− 20,000	−16
Washington	20	30,129	20	28,000	− 2,000	− 7
West Virginia	214	603,393	214	393,000	− 210,000	−35
Wisconsin	268	(1)	232	(1)	(1)	(1)
Combined States	(2)	2,523,684	....	2,519,000	− 5,000	− 0.2
Total	9,279	25,997,580	10,379	25,171,000	− 827,000	− 3

[1] Included in combined States.

[2] Includes Colorado, Michigan, Missouri, Rhode Island, and Wisconsin, combined to avoid disclosing operations of individual companies.

BY-PRODUCT OVENS COMPLETED IN 1919.

In 1919 a total of 1,228 new by-product ovens were completed, of which 718 were new plants and 510 were extensions at existing plants. Pennsylvania put the largest number of new ovens in operation—478. Indiana came second with 190, and Maryland third with 180. One new State, Rhode Island, entered the ranks of by-product coke producers in January, when the Providence Gas Co.'s plant was completed.

TABLE 5.—*New by-product ovens completed and put in blast in 1919.*

Company.	Location of plant.	Number ovens.	Type of ovens.	Date blown in.
New plants:				
International Harvester Co.	South Chicago, Ill.	88	Wilputte	Nov. 13, 1919.
Steel & Tube Co. of America	Indiana Harbor, Ind.	120	Semet-Solvay.	Aug. 28, 1919.
Ford Motor Co.	Detroit, Mich.	120	.....do	Oct. 14–Dec. 6, 1919.
Jones & Laughlin Steel Co.	Pittsburgh, Pa.	240	Koppers	June 18, 1919.
Rainey-Wood Coke Co.	Swedeland, Pa.	110	.....do	Aug. 26, 1919.
Providence Gas Co.	Providence, R. I.	40	.....do	Jan. 28, 1919.
Additions to existing plants:				
Tennessee Coal, Iron & R. R. Co.	Fairfield, Ala.	77	.....do	Dec. 17, 1919.
Citizens Gas Co.	Indianapolis, Ind.	40	Wilputte	Jan. 31, 1919.
Indiana Coke & Gas Co.	Terre Haute, Ind.	30	Koppers	Jan. 1, 1919.
Bethlehem Steel Corp.	Sparrows Point, Md.	[1] 180	.....do	Do.
Seaboard By-Product Coke Co.	Kearny, N. J.	55	.....do	Jan. 21, 1919.
Carnegie Steel Co.	Clairton, Pa.	128	.....do	June 3–July 1, 1919.
Total		1,228		

[1] Completed but not put in blast.

During the year 128 ovens were abandoned or were so rebuilt as to be classed as new ovens.

BY-PRODUCT OVENS UNDER CONSTRUCTION JANUARY 1, 1920.

Table 6 summarizes returns made to the United States Geological Survey from by-product operators on new ovens in construction at the beginning of 1920. In all, 853 ovens are scheduled to come into operation by July 1, 1920. Of these ovens, 247 are in Alabama, 220 in Pennsylvania, 210 in New York, and smaller numbers in Illinois, West Virginia, and Wisconsin. They are distributed among 11 projects, 6 of them new plants and 5 of them additions to existing plants.

TABLE 6.—*By-product ovens under construction Jan. 1, 1920.*

Operator.	Location of plant.	Number of ovens.	Type of ovens.	Probable date of operation.
Birmingham Coke & By-Products Co.	Birmingham, Ala.	50	Koppers	Mar. 1, 1920.
Sloss & Sheffield Steel & Iron Co.	.....do	120	Semet-Solvay.	May 1, 1920.
Tennessee Coal, Iron & R. R. Co.	Fairfield, Ala.	77	Koppers	Feb. 1, 1920.
St. Louis Coke & Chemical Co.	Granite City, Ill.	80	Roberts	June 1, 1920.
Donner-Union Coke Corp.	South Buffalo, N. Y.	150	Koppers	Do.
Lackawanna Steel Co.	Lackawanna, N. Y.	60	Semet-Solvay.	July 1, 1920.
Cambria Steel Co.	Johnstown, Pa.	60	Cambria-Belgian.	June —, 1920.
Jones & Laughlin Steel Co.	Pittsburgh, Pa.	60	Koppers	Apr. 1, 1920.
Pittsburgh Crucible Steel Co.	Midland, Pa.	100	.....do	June —, 1920.
Domestic Coke Corp.	Fairmont, W. Va.	60	.....do	May 1, 1920.
Steel & Tube Co. of America	Mayville, Wis.	36	United-Otto.	Jan. 1, 1920.
Total		853		

The completion of these projects will mean an increase of 8 per cent in the total number of by-product ovens in the country. Construction is more active now than in the years immediately before 1914, when the European war began, but is less active than it was during the war. Much of the construction now underway was projected before the armistice. The number of by-product ovens under construction in recent years has been as follows:

TABLE 7.—*By-product ovens in construction, 1914–1920.*

January 1, 1914	504
January 1, 1915	644
January 1, 1916	1,191
January 1, 1917	2,084
January 1, 1918	2,260
January 1, 1919	1,815
January 1, 1920	853

TYPES OF OVENS.

The following table shows the number of ovens of each type in existence on January 1, 1920, the number on January 1, 1919, and the number now under construction. Of the ovens put in operation in 1919, 860 were of the Koppers type, 240 were Semet-Solvay, and 128 were Wilputte.

TABLE 8.—*Ovens in use at beginning and end of 1919 and building Jan. 1, 1920, by type.*

	In existence Jan. 1, 1919.	In existence Jan. 1, 1920.	Building Jan. 1, 1920.
Koppers	4,829	5,659	497
Semet-Solvay	2,035	2,275	180
United-Otto	1,840	1,754	36
Rothberg	281	257	....
Wilputte	78	206	....
Cambria-Belgian	90	90	60
Gas Machinery	60	60	....
Klönne	42	42	....
Roberts	24	24	80
Piron	....	12	....
Total	9,279	10,379	853

PLANT CAPACITY FOR THE MANUFACTURE OF BY-PRODUCT COKE.

The capacity of a coke oven naturally depends upon the number of hours adopted as standard coking time. The maximum capacity of the by-product plants of the country, defined as "the maximum quantity of coke of the grade desired by the operator which can be produced when all conditions are favorable, with all ovens active," has been as follows:

TABLE 9.—*Maximum capacity of by-product coke ovens in the United States, 1918–1920, in net tons per annum.*

January 1, 1918	27,000,000
January 1, 1919	33,700,000
January 1, 1920	39,500,000

In the year 1918 there was thus an increase in the annual capacity of coke ovens amounting to 6,700,000 tons, or 25 per cent. The increase during the year 1919 was somewhat smaller, 5,800,000 tons, or 17.2 per cent.

The annual capacity of the plants completed and in operation at the beginning of 1920, including ovens temporarily idle, was 39,500,000 net tons. This figure represents the output at full capacity—operation of 100 per cent. In actual practice an average operation above 90 per cent can not be assumed for the country as a whole. Weekly reports received from the by-product plants during the war show that from December 28, 1917, to February 1, 1919, the highest percentage attained for the entire country was 92.2, the output reached in the week ended September 28, 1918. The average for the year 1918, when every effort was being made to speed up the recovery of by-products, was 86.9 per cent of maximum capacity. The average for 1919 appears to have been about 70 per cent.

In estimating the coke or the by-products recoverable from the country's existing by-product ovens the assumed percentage of operation should therefore not exceed 90 per cent. Indeed, the safer figure of 85 per cent would appear better justified by experience. The present capacity of the by-product ovens of the country in net tons per annum would therefore be that shown in table 10, the yield of coke from coal being taken as 71.2 per cent, the average for 1917–18.

TABLE 10.—*Capacity of by-product coke ovens in 1920.*

Assuming 90 per cent operation (coke), 35,500,000; coal for charge, 49,800,000.
Assuming 85 per cent operation (coke), 33,600,000; coal for charge, 47,100,000.

The completion of the plants now under construction may raise the capacity to a maximum of approximately 43,300,000 tons, or 36,800,000 tons under an operation of 85 per cent. In connection with the supposition that a limit to the production of by-product coke may be reached, it may be noted that this quantity is 65.2 per cent of the coke produced in 1918, the largest quantity ever used by the country in one year. It is 69 per cent of the coke required for producing 49,666,000 gross tons of pig iron, the annual capacity of the coke-burning blast furnaces completed or building on January 1, 1919, according to the annual statistical report of the American Iron and Steel Institute, the coke consumption being taken at 2,375 pounds per gross ton of iron. It is 61.7 per cent of the country's total requirements for coke in the war year 1918, as estimated by the United States Fuel Administration, less sales of gas-house coke, amounting to 1,814,000 tons.

RECOVERY OF BY-PRODUCTS.

Final statistics showing the quantity and value of by-products recovered in 1919 are not yet available, but an idea of the quantity may be obtained by multiplying the number of tons charged into the ovens in 1919 by the average quantity of by-products recovered in 1918 per ton.

TABLE 11.—*Average recovery per net ton of coal charged into by-product ovens in 1918.*

NH_3 (all forms) expressed in terms of equivalent ammonium sulphate	pounds	18.9
Tar	gallons	7.1
Crude light oil	do	2.4
Gas	M cubic feet	10.4

The figures, if multiplied by the 35,353,000 net tons of coal charged in 1919, as estimated from known coke production on yield of 71.2 per cent, the average for 1917–1918, would give 668,200,000 pounds of ammounium sulphate or its equivalent, 251,000,000 gallons of tar, 84,800,000 gallons of crude light oil, and 367,700,000 cubic feet of gas.

For purposes of comparison the actual production of by-products in 1918 is reprinted below.

TABLE 12.—*By-products obtained from coke-oven operations in 1918.*

Product.		Production.	Sales.	Value of sales.
Tar	gallons	263,299,470	200,233,002	$6,364,972
Ammonia:				
Sulphate	pounds	436,388,134	423,515,836	19,061,777
Liquor	gallons			
Anhydrous or free ammonia [1]	pounds	65,230,159	61,442,933	7,381,174
Gas:				
Illuminating and household purposes	M cu. ft.	385,035,154	33,437,991	7,130,113
Industrial purposes	do		124,920,488	6,569,402
Benzol products:				
Crude light oil	gallons	87,222,450	3,764,272	963,042
Secondary light oil	do	339,644	121,191	15,472
Benzol	do	44,804,900	43,441,980	11,966,367
Toluol	do	8,861,948	8,541,366	12,249,702
Solvent naphtha	do	3,540,162	3,123,815	439,983
Other oils	do	636,707	571,752	53,880
Crude naphthalene	pounds	10,614,799	10,403,758	287,581
Refined naphthalene	do	5,472,699	5,486,689	362,648
Other products [2]				1,756,345
Total				[3] 74,602,458

[1] Includes liquor and sulphate sold by pound of NH_3.

[2] Includes sodium ferro cyanide, pyridin oil, nut coke, drip oil, spent oxide, redisue, coal-tar paint and wash oil.

[3] Does not include value of 1,999,370 net tons of coke breeze.

If the figures showing the recovery of by-products per ton are multiplied by the number of tons given above as the annual coke capacity of the ovens now built and building in the United States, namely, 36,800,000 tons—a moderate estimate assuming 85 per cent operation—the annual capacity for the recovery of by-products by the end of 1920 will become 977,100,000 pounds of ammonium sulphate, or its equivalent, 367,000,000 gallons of tar, 124,000,000 gallons of crude light oil, and 537,300,000,000 cubic feet of gas.

Senator SMITH of South Carolina. Right in that connection, if you have the available figures, I would like to know about what is the cost of ammonium sulphate derived from the coke ovens per unit.

Maj. GAILLARD. What it costs them to make it?

Senator SMITH of South Carolina. What it costs them to put it on the market, if you have the figures available?

Maj. GAILLARD. We have not, sir.

Col. BURNS. You mean what they are selling it for, Senator?

Senator SMITH of South Carolina. I would like to know what is the cost for recovery—what it costs and what they are going to sell it at? No one is going to question their right to sell it on the market at a reasonably competitive price compared with other sources, because the combined sources do not provide an adequate supply. Therefore, the highest available source is going to measure the price of the others, and I presume they sell it per unit, like nitrate of soda or other forms of inorganic nitrogen. So that would not help us to get anywhere. What I really wanted to know was whether the profit was sufficiently large to encourage them to go still further and add other by-product ovens.

Maj. GAILLARD. As Prof. Whitney said this morning, sir, the matter of getting ammonia from coke ovens depends upon the demand for pig iron. They could not possibly put up ovens simply to get the ammonia from them. They could not replace the beehive ovens unless there was a demand for the by-products other than the ammonia.

Senator SMITH of South Carolina. I understood that; but the construction of these ovens to recover the ammonia, after they have added the heat units for producing their steel and other products, will largely depend upon the initial cost and the saving of this stuff at last. We do not plant cotton primarily for the seed, but it is very profitable for us to use the seed, which is a necessary and inevitable by-product. We do not do that now quite so much, but we do recover an amount by crushing the seed, converting it into meal and other forms.

Col. BURNS. We understand your question, Senator, but we have not the data that will allow us to answer it. As Maj. Gaillard says, the question of how much it costs to get it from the coke oven is pretty much a matter of bookkeeping. They may add the cost of separating out the ammonia to the coke, or they may add it to the oils, or they may add it to the gas, or they may add it to the ammonia, and they can declare the figures as they see fit.

Senator KENDRICK. One of the witnesses here testified, Colonel, that they would put any price on it as a by-product that they chose to make.

Col. BURNS. I think that is substantially correct, Senator, because they have three or four variables there, and if their final return is to be the same they can add it to one and subtract it from another, as they see fit. I think pretty nearly everybody agrees it is very difficult to set a cost on ammonium sulphate produced by by-product ovens.

Senator **Smith** of South Carolina. Under present conditions, it is a fact it has been pretty profitable for them to save this by-product.

Col. **Burns.** Oh, I think they do gain. The by-product coke ovens have had a wonderful field in the last six years, ever since the war started in Europe.

Senator **Smith** of South Carolina. I wish there were some way to ascertain whether or not there is quite a large margin of profit; because you can see that if competitors come into the field and begin to lower that margin our price will be dependent upon these competitors.

Col. **Burns.** We have had a general estimate prepared of what it costs to get ammonium sulphate from the by-product coke oven, and that estimate has been worked out on two bases—one charging against the ammonium sulphate its proper share of the capital investment, the proper depreciation and all that, and the other from the standpoint of not charging any capital investment and depreciation, but rather charging that against the coke and the other by-products. We can submit these estimates to you, if you care to have them. They are not backed up by our experience; they are simply estimates made for us by an outside agency.

Senator **Smith** of South Carolina. Unless it were some positive, direct statement, it would not be of any value in this connection.

Senator **Ransdell.** Colonel, do you know of any new ovens that have been constructed on the old bee-hive type recently, or are they making all of them by-product coke ovens?

Col. **Burns.** I can not give you any definite information on that, Senator, but I think they are still constructing new beehive coke ovens, because there are certain regions in the United States that are not yet sufficiently developed to absorb all of the by-products. Of course, the by-product coke oven is not economical unless you can dispose of all of your by-products at a favorable price. You have a lot of things, of course, produced by the by-product oven, and you have to find a market for them. The matter of profitably disposing of the surplus gas is one of the big considerations.

(At this point the hearing was suspended for 10 minutes to permit members of the committee to respond to a call of the Sergeant at Arms of the Senate, and was thereafter resumed, as follows:)

The **Chairman.** Major, you may proceed with your statement.

Col. **Burns.** Mr. Chairman, we would like to change the subject now slightly and go to the cost of producing and the probable selling costs for our products down there. Maj. Gaillard will discuss that, but before he does so, I would like to make this brief statement.

It has been pointed out by Mr. Washburn that the men who have been associated with this estimate have not had very much experience and that therefore their estimates should not be given a very great deal of weight. I should like to say that the estimates which we put in were prepared under the general direction of Mr. Arthur Glasgow, a man of broad business experience both in this country and in Europe and an engineer of high standing. He was assisted by Mr. Roberts, also an engineer as well as a man of extensive business experience, in estimating these additional charges that you must add to your straight production charges. The details of the work were performed by Maj. Gaillard, and I might say that he is not without experience along this very line, as for a while he was employed by the American Cyanamid Co. So it is not a new subject to him. I want to give you that idea so that you will be able to give whatever weight you see fit to our statement of costs.

The CHAIRMAN. The statement the major is going to make will be then practically in accordance with that of the men you have named—Mr. Roberts and Mr. Glasgow?

Col. BURNS. Yes, sir.

Maj. GAILLARD. Mr. Washburn has criticized the estimates that were submitted in Mr. Glasgow's letter on the ground that they were not figured on the basis of the present prices of materials. Neither was the selling price that we figured on, $65, the present price for sulphate. Of course, if the price of materials increases, the price of sulphate will increase. Speaking broadly, the prices of commodities go up and go down together. In order to see just what the effect would be of applying the present prices of materials and labor to our estimate, we refigured it, and we find that putting in the prices at which we can actually get the several raw materials required in the manufacture of sulphate, and putting in all labor at 10 per cent more than we had it in the former estimate—and that is a little more than Wilson Dam is actually paying down there now for labor—we find that our cost of production is less than 25 per cent more than we figured it.

The CHAIRMAN. In other words, you were 20 per cent too low in your figures?

Maj. GAILLARD. Yes, sir. But please understand, we did not claim our figures were the costs to-day; they were what we thought would be the costs in two or three years. We may be wrong, but in figuring the question of whether we could run or not and pay operating expenses out of sales we took the price of sulphate at $65 as compared with the probable price of $95 for next year. Our estimates for the cost of production were 20 per cent lower that they would be right at this minute, and the selling price of sulphate was about 30 per cent lower.

In regard to the probable selling price of sulphate, I would like to read a brief extract from an article in the April 19 issue of the Oil, Paint, and Drug Reporter, in the department headed Fertilizer Materials:

[Oil Paint and Drug Reporter, Apr. 19, 1920.]

FERTILIZER MATERIALS MARKET—NITROGEN FERTILIZERS.

Sulphate of ammonia.—Sulphate of ammonia production has been seriously reduced for the time being by the rail strike, which has stopped a great many of the coke ovens. This strike comes just at the time that production was attaining a new record since last fall's curtailment, and is tending to harden the market. Prices of sulphate in double bags for export are now holding up to $7.25 a hundred pounds, the range standing at about $7.10 to $7.25. No definite information is yet available on the new contract prices to domestic consumers. The leading interests have not entirely finished the computations on which they will base the prices. It may be said, however, that prices will be over $4.50 and under $5 a hundred pounds for sulphate in bulk. This is a higher figure than had been anticipated a month or two ago, but conditions have changed since then.

Domestic demand is still strong and will continue steadily through the summer and fall, according to all indications. Foreign demand comes largely from nations which were the smaller purchasers before the Great War. The big European nations are buying almost no sulphate now, because of the disparity of exchange.

You will notice this says that the contract price for next season for sulphate in bulk, not in bags, will be from $4.50 to $5 a hundred pounds, or from $90 to $100 a ton.

Mr. Washburn submitted a set of cost figures to the committee two or three days ago, and he very kindly gave us a copy of them. He shows a total cost for sulphate made with steam power, not water power, of $91.61. Our estimate of the cost of sulphate made with water power at the present prices of materials is $58. As compared with the figure of $48 that occurred in Mr. Glasgow's letter, that is an increase, owing to the fact that prices of material and of labor are higher at this time than we had assumed in those estimates.

In looking at the details of Mr. Washburn's estimate, the first thing we notice is the fact that he has limestone at $2 a ton. After Mr. Washburn testified we consulted with two men who are actually quarrying limestone now in considerable quantities, one in Pennsylvania and one in Tennessee, and who are familiar with the layout of our limestone quarry, as to what our probable cost of production would be. Their estimates ranged from 70 to 90 cents a ton at the quarry. In addition to that there is a freight rate of 60 cents a ton to get the stone to the plant. Taking the higher of those two figures, 90 cents, and adding the 60 cents to it we have $1.50, which is what we used in refiguring our own estimate.

Senator KENDRICK. Does your 90 cents include loading on the cars?

Maj. GAILLARD. Yes, sir; it also includes repairs, maintenance of quarry equipment, and all the operating charges. That is not a vitally important item, but it makes a difference of about a dollar a ton of sulphate and indicates one of the differences between our estimate and that of Mr. Washburn.

The next item of Mr. Washburn's that we criticize is the estimate of the cost of steam. He has steam in here at 60 cents per 1,000 pounds. In this same estimate he also has steam power at 3.9 mills per kilowatt hour. Now, the cost of steam vitally affects the cost of steam power. Even with our most efficient steam power plant down there the best we can hope to do is to use 13 pounds of steam to make 1 kilowatt hour, and that is a very good performance. The smaller central stations use very much more steam than that. Thirteen pounds of steam at Mr. Washburn's figure of 60 cents amounts to 7.8 mills for the steam that we use to make the electric power, and yet he has the electric power in at 3.9 mills—just half. He takes that steam and runs steam turbines with it, all of which certainly costs something, and yet he figures his electric power at half of what the steam costs. In other words, we think his figure for steam is entirely too high—60 cents per 1,000 pounds—and entirely out of line with the figure he has assumed for his steam power. We accept his figure for steam power. He has 3.9 mills; we had 4 mills, practically the same.

The estimate for steam in Mr. Glasgow's letter was 28.5 cents per 1,000 pounds. With the increased cost of coal and labor we estimate the present cost at 34 cents. Estimates independently obtained within the last week from the J. G. White Engineering Corporation, who operate many steam plants in this country; from Westinghouse, Church, Kerr & Co., who designed and built the particular steam plant at Muscle Shoals that we are considering, and from that board of the Army who operate the steam plants at all military posts, show a cost of producing steam under the actual conditions that will prevail at Muscle Shoals, with the present price of coal and labor there, ranging from 30.5 to 36.5 cents per 1,000 pounds. And yet Mr. Washburn uses a figure of 60 cents.

I would now like to read what Mr. Washburn says:

> It is to be noted also that while the Government's general items referred to above are less than actual costs, they are accepted in order to make it clear that I am joining issue with the Government solely by substituting material costs and adding items overlooked and unknown to the Government.

One of the items that he says was unknown to us is the item "replacements." He has an item in for maintenance, repairs, and renewals, and he has still another item, replacements. We have not had sufficient actual experience in operating the Muscle Shoals plant to determine whether his figure is correct or not, and all we can do is to see whether it is reasonable or not. Adding up his items for maintenance, repairs, renewals, and replacements gives us about $2,700,000, which is what he says it will cost every year with that plant running to keep it in repair..

Mr. Washburn submitted to us, under date of December 28, 1918, an estimate of the cost of making ammonium nitrate at Muscle Shoals. It is a very long letter, and unless the Committee desires it was not my intention to insert it in the record. It also contains certain of Mr. Washburn's own costs that I do not know whether he would care to have put in the record or not. If he requests it, however, we will put the whole letter in. He says:

NEW YORK CITY, *December 28, 1918.*

Col. F. H. WAGNER,
Director of Operations, representing contracting officer,
72 Roland Avenue, Roland Park, Baltimore, Md.

DEAR SIR: Inclosed are a series of projected estimates of the cost of producing ammonium nitrate at United States Nitrate Plant No. 2, Muscle Shoals, Ala. They have been prepared as a result of your verbal request made on the 21st instant upon our vice president at Muscle Shoals, Mr. J. T. Fetherston. * * *

FIRST SERIES.

A sheet showing the estimated cost of ammonium nitrate at one-third, two-thirds, and three-thirds production, with the cost of coal delivered at the plant taken at $4.65 per ton. This is the principal estimate, and the one, from our understanding of your purpose in having an estimate, of chief importance. This is based upon unit prices of materials and labor as they exist to-day, and, for the most part, as to efficiencies and quantities upon the observed results of the operation of the Muscle Shoals plant up to the present time.

* * * * * * *

In the matter of supplies, the estimated cost of supplies, repairs, and renewals, for which we have as yet no figures of performance at Muscle Shoals, is based upon plant records of the American Cyanamid Co.

* * * * * * *

SUMMARY.

The projected estimated cost of ammonium nitrate per pound at the Muscle Shoals plant, based upon conditions as they exist to-day as to unit prices of material and labor, assuming all the power to be secured from the steam electric-power plant on the Tennessee River, with coal at $4.65 per ton, is shown by this series of estimates to be for one-third the capacity of the plant, 7.05 cents per pound of ammonium nitrate; two-thirds the capacity of the plant, 5.62 cents per pound of ammonium nitrate; full capacity of the plant, 5.02 per pound of ammonium nitrate.

* * * * * * *

We have to ask that the information contained herein shall be so used by the Government as not to permit it to become public property or to fall into the hands of present or possible future competitors of the American Cyanamid Co. This would seem to us to be only reasonable and proper safeguarding of the rights of the American Cyanamid Co., and will be quite in accordance with the provisions of the existing contract between the American Cyanamid Co. and the United States Government.

Very truly, yours,

AIR NITRATES CORPORATION,
FRANK S. WASHBURN, *President.*
AMERICAN CYANAMID CO.,
FRANK S WASHBURN, *President.*

And then he proceeds to give items for maintenance, repairs, and renewals, which add up to $915,000 a year. He says now it is going to cost some $2,700,000 a year at that plant for repairs, maintenance, and replacements. This replacement item is a new one; he did not consider it a part of the cost of production in 1918, but apparently it is in 1920. His earlier figure was $915,000. His present figure is $2,700,000. Commodity prices since January, 1919, have increased about 25 per cent, so it might be proper to take his 1919 figure and assume one and a quarter times that as what it should cost today. That cost of $2,700,000 spread over the total production of sulphate amounts to $13 a ton of sulphate. The figure that he used in 1919 for the annual cost for repairs and maintenance of the plant, spread over the quantity of sulphate that could be made, is $4.50, a difference of $8.50 a ton of sulphate.

Of course, we have had no experience in repairs and maintenance at all, except that one manufacturing plant is not so very different from another one; and the figures that Mr. Glasgow and Mr. Roberts put down for that item—and that item was estimated by them, because I had had no experience that qualified me to estimate what such items would be—would be a little more—I think, $930,000 a year—than Mr. Washburn had in his January, 1919, estimate. That, of course, is but slightly more than a third of what he now says—$2,700,000.

His factory general expense item, which includes the overhead, is $6.50, as opposed to our item of $2.50. There again it is a question of opinion.

Another thing that Mr. Washburn does, as I have said before, is to figure on steam power at 3.9 mills instead of water power at three-quarters of a mill, as we have. Then he adds in bagging and loading at $4, although we estimate that only a third of our product will be bagged, that two-thirds of it will be shipped in bulk, and that the selling price of $95 a ton refers to sulphate in bulk; and if you are going to compare the cost of making it with the selling price in bulk, it ought to be the cost of making it in bulk.

Mr. Washburn gives a total cost of $91.61. Three dollars of that is interest on this additional $12,500,000. The Government has the nitrate of soda now and is paying interest on it, and if we change the Government's investment from nitrate of soda to fixed and liquid assets in a nitrate plant it does not affect the interest question at all, and no interest should be charged in.

This difference of steam power versus water power amounts to $9 a ton of sulphate. The fact that he has figured all the product as bagged instead of one-third of it, as we estimate—and we might with perfect logic assume that we would bag none of it—would take $14.65 off of his costs just for those three items—interest, water instead of steam power, and bagging—that would reduce his estimated cost to $77 a ton of sulphate. That is leaving in his item for repairs at $13 a ton, leaving in his limestone at $2 a ton, leaving in the steam at double the cost of the electric power that can be made from the steam and at practically double what independent engineers estimate the cost to be, he would have $77 a ton, and the selling price as estimated for next year is $95 a ton. That is a difference of $18 a ton, and Mr. Glasgow showed a difference of $16 a ton. In other words, we have a little more margin than we had before, even accepting all of Mr. Washburn's figures at their face value.

The CHAIRMAN. You feel certain, then, Major, that—including everything as you have stated it—the Government would be able, or anyone would be able, to produce this compound at $77 a ton?

Maj. GAILLARD. Yes, sir; that would be the manufacturing cost—no interest, no depreciation, no taxes. That would be the actual factory expense, the out-of-pocket expense. It does, though, include repairs and maintenance of the plant.

Senator SMITH of South Carolina. What percentage of equivalent nitrogen is there in that sulphate of ammonia?

Maj. GAILLARD. That has 20.5 per cent of nitrogen in it—about one and a third times as much as the Chilean nitrate.

There is another thing I would like to mention, and that is that Mr. Washburn testified regarding costs before Mr. Graham's committee in the House, the committee investigating war expenditures, and Mr. Graham said:

> We have nothing here before us, that I recall, except the Glasgow report on this cost of production that appears in the Vining report, and, I believe, some other witness did testify somewhere along the line in a general way about what he thought the cost would be per ton. But I do not now remember who that was. However, if Col. Burns or you people made any estimates of cost of production I would like to see them.
>
> Mr. WASHBURN. That will be placed before you. We will find the Burns figures and present them, so that you can either take them as we present them or by going to the source you can get them; and we will present any figures that are our own deductions, if they vary from Col. Burns's report.
>
> Mr. GRAHAM. As I understand you now, you say that your figures were 5 to 10 per cent higher than Burns's.

I want to add right there that the figures Mr. Washburn is talking about were some preliminary figures we made last spring. For instance, on ammonia they amounted to $146.60 a ton. The figure in Mr. Glasgow's letter, which was calculated afterwards, amounted to $139.63, a difference of $7. In other words, the figures that Mr. Washburn was talking about were a little bit higher than the ones in the Glasgow letter, but only to the extent of $7 out of $140, about 5 per cent higher. Mr. Washburn says:

> An estimate which we made before the plant was placed in operation, and shortly before it was placed in operation, as to the ultimate cost of material,

with the plant working under normal conditions, was within 5 to 10 per cent of the figure that Col. Burns determined to be the normal cost, after the plant had completed its operations.

Then Mr. Jefferis, of the committee, asked Mr. Washburn:

> Your estimate, as I understand it, was either 5 or 10 per cent above that, Mr. Washburn, or below it?
>
> Mr. WASHBURN. Our estimate was 5 to 10 per cent above it, not applied to the complete operation, but applied to the costs of the material at the stage of producing the ammonia.
>
> Mr. JEFFERIS. What do you think of your estimate now?
>
> Mr. WASHBURN. It, of course, is an estimate that has not the substantial basis that Col. Burns's estimate has, because he made his estimate from deduction from actual operating figures, while we made our estimate from our knowledge of the art as practiced in a small plant under different conditions. But it is a remarkably good check, I should say, that the two should come out within 5 to 10 per cent, which is as close as human estimates can be made to correspond reasonably.

Col. BURNS. I would like to add, in order to clear up the situation, that that estimate was really made by Maj. Gaillard at the time, and not by me. I submitted it, but it was his work.

Maj. GAILLARD. In other words, on an estimate that was 5 per cent higher than Mr. Glasgow's, Mr. Washburn said then we were within 5 or 10 per cent of correct.

Senator KENDRICK. You made your test at the Muscle Shoals plant?

Maj. GAILLARD. Yes, sir. Our quantities of raw materials, our labor requirements, and the amount of power necessary are based on the test that was conducted down there, a two weeks' operating test after the plant had been running two or three months. We measured the materials that went in carefully, and Mr. Washburn takes no exception to the quantities. He probably does not agree with us on all of them; on some of them he would probably be higher and on some lower.

Senator KENDRICK. What part of the machinery did you have in actual service at the time?

Maj. GAILLARD. About one-fifth of it, sir; but it was straight through from one end of the plant to the other. That involved experience with units that, we thought, would show what the plant could do running at full capacity.

Senator KENDRICK. That must have been a fairly representative test?

Maj. GAILLARD. Yes, sir. It certainly was a conservative test, made with a green crew, and the plant having run only two and a half or three months at that time. It certainly seems reasonable that if you would go down there and operate regularly you ought to do better than that. But we have assumed in these estimates just the results that were actually obtained during the test.

Senator KENDRICK. Did you run the plant continuously during that time?

Maj. GAILLARD. Yes, sir; it was a two weeks' test, day and night. Of course, the plant has to run day and night anyhow—24 hours a day, 7 days a week—practically all parts of it.

Senator KENDRICK. Is a continuous operation throughout every day in the week necessary in the production of this material?

Maj. **Gaillard**. Yes, sir; at least, it is necessary to get economical production.

Senator **Smith** of South Carolina. You said a moment ago that sulphate of ammonia had about 20 per cent nitrogenous content?

Maj. **Gaillard**. Yes, sir.

Senator **Smith** of South Carolina. As against 15 per cent for Chilean nitrate. That is about one and a third more. You were making this test, presumably, at the very peak of the cost of everything that entered into the operation of that plant?

Maj. **Gaillard**. We thought so at the time, sir; but some of the prices are higher now.

Senator **Smith** of South Carolina. But they are not as much higher now as they were then compared with prewar prices?

Maj. **Gaillard**. No, sir.

Senator **Smith** of South Carolina. That is what I am getting at. Now, the use of this ingredient in fertilizer is going to depend to a greater degree than on any other thing that would affect it, upon the cost of it?

Maj. **Gaillard**. Yes, sir; absolutely.

Senator **Smith** of South Carolina. If we can not cheapen the cost of it to where it could be economically used for fertilizer, it would be an idle thing for us to attempt to manufacture it. If a competitor can come into the field and preempt the whole business and cause us to run at a loss, it will be idle for us to go any further. Besides, we know of no limit, at least in our generation and the few to follow, to the Chilean mines. I have a pretty good idea, I think, about the supply that is available there at the present rate of consumption or with the indicated additional rate. So unless there is a real basis for us to believe that we can get the thing perfected and running at a materially lower cost than this other material, it might not be the proper thing for us to go further.

Senator **Kendrick**. Senator Smith, I do not believe that your conclusion there is justified by the facts. First, we must recognize the possibility of a shortage of the Chilean nitrates. There is reason, as I understand it, to believe that that is a fact. Then there is another consideration in connection with it. Suppose there should be some process of producing these nitrates more cheaply than they can be produced now under the system that we have installed; it would necessarily follow that the Government would participate in the advantages to be derived from that improved process.

Senator **Smith** of South Carolina. Senator Kendrick, I am simply trying to emphasize the necessity of this Government's using every effort to bring about two things: An adequate supply of this ingredient, and at the lowest possible price. That is what I was trying to emphasize, and I was a little bit surprised when I heard it would cost about $77 a ton.

Maj. **Gaillard**. No, sir; pardon me, sir. We say $58 at the present cost of labor and materials. I said $77 if we accepted Mr. Washburn's figures.

Senator **Smith** of South Carolina. Oh, $58? With 20 per cent nitrogen content?

Maj. **Gaillard**. Yes, sir.

Senator **Smith** of South Carolina. Nitrate of soda is now selling at about the same price, at ship side, plus freight. That is a different proposition.

Maj. **Gaillard**. Yes, sir. I was trying to show that, even taking Mr. Washburn's figures, the cost of production would probably be $18 under the present market.

Senator **Smith** of South Carolina. In other words, under the present price of soda, you are just about competing with nitrogenous content, or maybe a little under?

Maj. **Gaillard**. Yes, sir.

Senator **Smith** of South Carolina. Then it is reasonable to suppose that if conditions are such that nitrate would have to recede, you would get in a position to meet the lowering price. That is all right; that is the point, because if the present price of sulphate of ammonia was approaching that of nitrate of soda, we might suppose that unless you could devise some means to reduce the cost as the conditions of living got more stable, you would still have that difference between the present sources of nitrogen and yours.

Senator **Ransdell**. I would like to ask the major just one question. What is your information, Major, about the amount of nitrate of soda in the Chilean mines? I am under the impression it is not limitless by any means, but that it will give out just as the guano gave out.

Maj. **Gaillard**. There are various estimates as to how much there is. This, again, involves the question of how much nitrate is going to be used, and how much can be paid to get it out. Those deposits first to be mined are the ones richest in nitrogen, because those are the cheapest producers—the ones that run the highest in nitrate. Then as they have to go farther and farther afield and mine the ones less and less rich in nitrate the cost becomes greater, and the statistics of production in Chile show that the percentage of nitrate has been going steadily down in the dirt they make it from.

Senator **Ransdell**. The rich deposits have been pretty nearly exhausted.

Maj. **Gaillard**. They are becoming exhausted, and that has a very close relation to the question of what the cost is going to be. Of course, if the cost of nitrate should be high enough to pay them to refine a lot of material which they are now throwing away, and when you say, "How much is there?" it is a question of the cost; it is a question of how much is there that it is going to pay you to get out.

Senator **Smith** of South Carolina. There are still unexplored and undeveloped fields whose richness has not yet been determined, because when I had this question up before with Prof. Whitney here and others we went right at that pretty fully, and I believe he represented here again this morning that it was rather indefinite as to the time when nitrate from Chile would not be available even in its present form. And I take it it will be a considerable number of years; at least he said this morning it would not need to give us any trouble as to the exhaustion of that supply. But that is a foreign supply?

Maj. **Gaillard**. Yes, sir.

Senator **Smith** of South Carolina. And if we can get one just as available here it is our business to do it?

Maj. **Gaillard**. It certainly is.

Gen. **Williams.** In so far as the Ordnance Department is concerned, our prime interest in this plant is maintaining it as a war insurance, on account of the fact that we are absolutely dependent on foreign sources for our supply of nitrogen, and we can imagine our position in case we got into a war and lost control of the sea. We would not then be able to maintain a war for six months unless we have plants of this kind.

Senator **Smith** of South Carolina. I believe it was also brought out, General, that if you had this plant that would produce 150,000 tons of nitrate it would relieve you from the necessity of carrying in stock 150,000 tons.

Gen. **Williams.** Yes, sir; that is quite true also.

Maj. **Gaillard.** Are there any other questions?

Col. **Burns.** One of the points that has been brought up is the one that Senator Smith has just spoken of, about the reduction in our stocks of sodium nitrate, and I believe that he wanted to hear a few things more about it after the Secretary of War discussed it yesterday.

Senator **Kendrick.** Yes; we would like to hear about that.

Col. **Burns.** And I would like to give you a very brief idea of how we came to the conclusion that we could dispose of 150,000 long tons of sodium nitrate.

Of course all powders and explosives are made from nitric acid; that is admitted as a fundamental fact; and, of course, in the long run nitric acid is produced from sodium nitrate, but there are other ways of producing nitric acid. You can oxidize ammonia and produce nitric acid. That is exactly the method that was pursued by the Germans, because they did not get any Chilean nitrate and they had to get it from other sources, and they took the ammonia which they obtained from by-product coke ovens and which they obtained by means of the Haber process in Germany and the cyanamid process in Germany, and they oxidized that into the form of nitric acid, and they used it in the manufacture of their powder and explosives.

The No. 2 plant at Muscle Shoals is thoroughly equipped to oxidize ammonia which it makes down there, and convert it into nitric acid, and our figures are to the effect that it can oxidize in one year nitric acid equivalent to 150,000 tons of sodium nitrate, but in the form of nitric acid. It is admitted that the distribution of that nitric acid to the explosive and powder companies is not entirely worked out. That would be one of the problems which this corporation would have on its shoulders.

You can distribute it as nitric acid, but it is quite a mean task, because you have got to mix it with sulphuric acid, which would have to be sent down there. But there is another way the Germans used; they converted that nitric acid which they made from ammonia back into sodium nitrate through a synthetic process, and then they distributed this sodium nitrate to the various powder factories and to the various explosive factories in exactly the same way that they would if they were getting sodium nitrate from Chile. We have the way to make sodium nitrate synthetically from such a plant as we have at Muscle Shoals.

It is quite a complicated problem really to find out what stock of sodium nitrate you must have on hand. But to go at it generally, we, after the armistice, figured out what we should have, and we laid down sufficient nitrogen to maintain a reasonable-sized army for 15 months. A part of that was in the form of ammunition, part of it was in the form of powder and explosives, and 300,000 long tons of this same nitrogen was in the form of sodium nitrate. I say that whole amount of material was to supply an army for 15 months. As I said, also, the Muscle Shoals plant can make the equivalent of 150,00 long tons per year. Therefore we are just taking practically a year's output of the Muscle Shoals plant and applying it against this program which is to cover 15 months anyway.

Senator SMITH of South Carolina. That is to say, in case you would enter war you would use the No. 2 plant at Muscle Shoals for the production of 150,000 long tons of nitrate?

Col. BURNS. Yes, sir.

Senator KENDRICK. In other words, in about one year, we will say, with the plant in full operation, you would replace the 150,000 long tons that you had disposed of?

Col. BURNS. Yes, sir; in about a year.

Senator KENDRICK. With the plant in full operation?

Col. BURNS. Yes, sir; and that gives us a 25 per cent factor of safety by taking only one year to produce a supply for 15 months. So that if you did not start in for three months you would still be in good shape.

Senator KENDRICK. The production would keep step with the consumption?

Col. BURNS. Yes. Of course, there is more to it, Senator, because in a long war you would undoubtedly have to have more nitric acid than you could get out of No. 2 plant, but you would have that plant that you could expand or duplicate, which would be an added military asset over and above the plant not being in operation.

The first amount of powder and explosives, etc., was all figured on the assumption we would not have this No. 2 plant, for its future is too uncertain to depend on, and I still think it would be good military policy if we could not get this No. 2 plant to operate not to give up a pound of this sodium nitrate except for a temporary period; we could not afford to.

Senator KENDRICK. Is it not reasonable to assume that with the plant in operation that we could soon, if we thought best to do so, reinforce our supplies from the production of the plant?

Col. BURNS. Yes, sir; it is perfectly possible.

Senator KENDRICK. Which would bring our supply to normal again, if we saw fit to do so, without interrupting the commercial business materially?

Col. BURNS. There is one thing I want to make clear, and that is that No. 2 plant as it is to-day can make nitric acid, but it can not put that nitric acid into the form of sodium nitrate, but the step to do that is really very minor.

You can make ammonium nitrate to-day, which, of course, is a good explosive, but you can not make sodium nitrate. You can use ammonium nitrate for the manufacture of nitric acid, although it is not as economical as the other way, because all of your nitrogen would not be converted into the nitric acid.

Senator KENDRICK (presiding). Have you any other questions?

Col. BURNS. There are one or two more points I would like to bring out that I think perhaps have been touched on, but I would like to try to emphasize them again, if I might.

Mr. Washburn in discussing this bill indicated that it was unfair to his company in general, and in particular stated that it gives the Government condemnation rights. That condemnation right that he speaks of comes from the National Defense act which is already a law, and the power rests with the Government at this minute to condemn processes for the fixation of nitrogen when it sees fit to do so. It has had that power since 1916, and it apparently has not misused that power. I can not see that Mr. Washburn has any great reason to fear that it will be misused in the future.

Senator KENDRICK. Under the plan of the agreement that you have made with Mr. Washburn's company, it would be unnecessary to condemn it, would it not?

Col. BURNS. Yes, sir; it would be absolutely unnecessary. But he referred to another matter, the use of cyanamid as fertilizer, which he claims is not within the contract rights.

He indicated quite strongly that apparently the Government was not proposing to live up to its contractual obligations. It seems to me that that should not go unchallenged, because I do not think it is fair to assume that the Secretary of War or such responsible officers as he would appoint to do this work for him would not live up to their contractual obligation. I do not think any further argument on that score is necessary, except that I do not like to see that go into the record without saying something about it.

With reference to the protection which he has—you have just mentioned it, Senator—I would like to show what royalty he would get if this plant were operated on a 100 per cent basis in accordance with the Glasgow report. His royalty would amount per year to $1,315,775. Now, it seems to me that that is pretty good protection, and that his company does not have to fear very much competition.

Senator SMITH of South Carolina. Do I understand that that $1,300,000 is the royalty you pay simply for the use of his patents?

Col. BURNS. Yes, sir.

Senator SMITH of South Carolina. You bearing all other expenses?

Col. BURNS. Yes, sir; if we paid the royalties that now exist in the contract. Of course, the contract says we can ask for arbitration on those royalties, and I have no doubt but that arbitration would be asked for, because we feel that is a pretty high royalty. But I wanted to bring out the amount of money that this contract might give to the American Cyanamid Co.

I think it might be well to have a copy of the contract in the record, if you care to have it.

(The contract between the Air Nitrates Corporation and United States of America and the American Cyanamid Co. of the United States of America, submitted by Col. Burns, is here printed in full as follows:)

[Order No. War—Ord. P 9771—1029 ET 1006—Cont. T—66.]

AIR NITRATES CORPORATION AND UNITED STATES OF AMERICA; AMERICAN CYANAMID CO. AND UNITED STATES OF AMERICA, ORDNANCE DEPARTMENT, UNITED STATES ARMY—CONTRACT FOR ERECTION AND OPERATION OF THREE AMMONIUM NITRATE PLANTS AND LICENSE AGREEMENT IN RELATION THERETO—DATED AND EXECUTED JUNE 8, 1918.

This contract, made this 8th day of June, 1918, by and between Air Nitrates Corporation, a corporation organized under the laws of the State of New York (hereinafter called the "agent"), party of the first part, and the United

States of America, by Samuel McRoberts, colonel, Ordnance Department, National Army (hereinafter called the "contracting officer"), acting by and under the authority of the Chief of Ordnance, United States Army, and under the direction of the Secretary of War, party of the second part,

Witnesseth: Whereas a state of war exists between the United States of America and the German and Austro-Hungarian Governments, constituting a national emergency, and the United States requires the performance within the shortest possible time of the work hereinafter described; and

Whereas the American Cyanamid Co., a corporation of the State of Maine, is the producer of certain chemicals by the so-called "cyanamid processes" necessary for the production of ammonium nitrate, and is familiar with and controls exclusive patents and processes for the production of such chemicals in this country, and proposes to assist the United States in perfoming this contract as follows:

1. By licensing the United States and the said Air Nitrates Corporation as agent of the United States to use its patents and processes.

2. By placing at the disposal of the said Air Nitrates Corporation all its experiences, records, and plans appertaining to the production of the said chemicals.

3. By placing at the disposal of the said Air Nitrates Corporation certain members of its executive and technical force for the construction and operation of the plants hereinafter mentioned.

4. By placing at the disposal of the said Air Nitrates Corporation all its plants for the purpose of training superintendents, foremen, and chief operatives.

And the United States proposes to compensate the American Cyanamid Co. for the foregoing, as set forth in a contract marked "Exhibit 1," bearing even date herewith and annexed hereto; and

Whereas the said company is unwilling to subject its property and assets to liability in connection with the planning, construction, and operation of the proposed plants, and has accordingly organized the Air Nitrates Corporation (the agent under this agreement), which shall act as the agent of and which shall be solely responsible to the United States and others in the planning, construction, and operation of the proposed plants, and according to the terms hereof; and

Whereas the United States entered into a contract with the said Air Nitrates Corporation, under date of November 16, 1917, for the construction and operation, as agent for the United States, at Muscle Shoals, Ala., of a plant for the manufacture of ammonium nitrate, of an approximate capacity of 110,000 short tons of ammonium nitrate per annum, hereinafter referred to as the Muscle Shloals Plant, and work thereon has been commenced; and

Whereas it has now become necessary that two additional plants, each with a capacity of approximately 55,000 short tons of ammonium nitrate per annum, shall be constructed and operated at sites to be selected as hereinafter provided; and

Whereas it is desirable that a new contract be entered into for the construction, completion, and operation of all the said plants of an approximate aggregate capacity of 220,000 tons of ammonium nitrate per annum, such new contract to supersede by mutual consent of the parties hereto and in accordance with the best interests of the United States said contract of November 16, 1917:

Now, therefore, in consideration of the mutual agreements herein contained the said parties have agreed and by these presents do agree with each other as follows:

ARTICLE I. *Exclusive services.*—The agent shall engage exclusively in the work of executing this contract, including the designing, constructing, and operating of the plants herein described. It shall use its best endeavors to construct the said plants as quickly as practicable, and at the least possible cost consistent with the proper performance of this contract. This shall include availing itself of the cooperation of the American Cyanamid Co. to the full extent contemplated in this contract and the one of even date herewith between the United States and the American Cyanamid Co., hereunto attached and marked "Exhibit 1." The agent will maintain such departments as shall be necessary or appropriate for the carrying out of this agreement, including engineering, administrative, purchasing, construction, manufacturing, inspection, labor relations, workmen's compensation, statistical, commissary, police, fire, medical, housing, accounting, and legal departments.

ART. II. *Muscle Shoals site.*—The agent shall, at the cost of the United States, conclude the negotiations heretofore begun for the acquisition by and in the name of the United States of the site on which said plant at Muscle Shoals is now being constructed.

Selection and purchase of sites for new plants.—The agent, acting as agent for and at the cost of the United States, shall forthwith select two sites, each suitable for the construction and operation thereon of plants of the character hereinafter described for the production of ammonium nitrate. After such sites shall have been severally approved in writing by the contracting officer, they shall be secured at the sole cost of the United States and be conveyed to the United States of America by deeds in form and substance satisfactory to the contracting officer, subject only to such liens and incumbrances as the contracting officer shall approve in writing. The deeds shall be properly executed and acknowledged in form for recording in the counties in which the sites are located.

ART. III. *Plans for and construction of plants.*—The agent, acting as agent for and at the cost of the United States, agrees—

1. To proceed with and complete the planning, laying out, constructing, erecting, installing, and equipping of the said plant at Muscle Shoals with an approximate capacity as aforesaid, and to furnish all necessary labor, tools, machinery, and materials, and to do all other things necessary or appropriate thereto. All plans and specifications in relation to said plant heretofore approved by or on behalf of the chief of ordnance or the contracting officer shall be considered for the purpose of this agreement as having had the approval of the chief of ordnance and the contracting officer.

2. To plan, lay out, construct, erect, install, and equip at each of said two new sites a complete plant, with an approximate capacity as aforesaid, for the production of ammonium nitrate, furnishing all necessary labor, tools, machinery, and materials, and doing all other things necessary and appropriate in the premises.

Each of said plants shall include the necessary land; also necessary lime, carbide, nitrogen gas, lime-nitrogen, ammonia, nitric acid, and nitrating plants; also all necessary temporary buildings, houses for employees, administrative buildings, laboratories, shops, warehouses, hospitals, stores, commissaries, structures, lines of communication and transmission, plant machinery, railway and trolley tracks, dredging, docks, boiler plants, roundhouses, roads, ways, waste disposal and sewerage, water and lighting systems, locomotives, cars, fixtures, tools, equipment, apparatus, and appurtenances; also power houses adequate for the development and transmission of such power for the operation of said plants as can not be advantageously obtained through outside sources or agencies; also gravel pits, limestone quarries, coal mines, and other things, to such extent and in such manner as may be reasonably necessary for the prosecution of the work contemplated by this contract; but no coal mine shall be acquired without the written approval of the contracting officer.

ART. IV. *Operation of plants.*—The agent, acting as agent for and at the cost of the United States, agrees, as and when any part or parts of said plants are sufficiently completed and ready for operation, forthwith to proceed to operate the same and to continue the operation thereof up to June 1, 1921, and thereafter for so long as the United States shall remain in the present war, subject to the provisions of Article XVII hereof. The agent shall do all things necessary or appropriate in and about the operation of said plants, including the procurement of all necessary labor and power and the purchase of all necessary materials.

Operation under this article shall include placing ammonium nitrate produced hereunder, as from time to time directed, on cars or lighters or in warehouses at the site of the plant where manufactured.

Revenue from housing, etc.—Any revenue from the operation of any housing, boarding houses, commissary, stores, infirmary, hospital, or other facilities, or from rebates, refunds, etc., shall be accounted for by the agent to the United States.

ART. V. *Materials.*—The United States may at any time furnish the agent any materials necessary for use in the performance of this contract.

ART. VI. *Agent to follow directions.*—The agent shall from time to time consult with the contracting officer upon the general character of the work contemplated. Upon written request, made from time to time by the contracting officer, the agent shall inform the contracting officer at the earliest practicable time as to any plan, contract, purchase, and method contemplated in the construction and operation of the plants and properties, and the United States may reject, or from time to time require the agent to modify, any such plan, contract, purchase, or method, or to substitute therefor and carry out such other plans, contracts, purchases, or methods as in the judgment of the contracting officer may be in the interest of the United States, all at the expense of the United States. The agent in the planning, constructing, equipping, and operation of the plants shall abide by such directions as the contracting officer shall from time to time give the agent. All such requests and directions shall be in writing, or by telegraph, addressed to the agent at its address hereinafter stated.

ART. VII. *Specifications.*—The processes and work involved in the manufacture of the final product of ammonium nitrate to be produced hereunder shall be conducted so that said final product may be in accordance with such specifications as the Ordnance Department may from time to time adopt for ammonium nitrate to be manufactured under this contract.

ART. VIII. *Processes.*—The said plants shall be constructed for operation under the cyanamid process, unless the United States shall direct that some other process be used, in which case all changes in construction thereby necessitated shall be made by the agent at the cost of the United States.

If at any time hereafter in the judgment of the Chief of Ordnance the oxidation of ammonia and its conversion to dilute nitric acid or the manufacture of ammonium nitrate from dilute nitric acid by interaction with ammonia may be done more advantageously by improved methods or processes of persons or companies other than the agent, the Chief of Ordnance shall be free to call upon the agent to install and use such methods or processes in its operation of the plants, at the cost and expense of the United States. The Chief of Ordnance shall be free to consult with parties other than the agent upon all matters relating to the operation of the plants, to the end that the best results of operation may be obtained.

The agent shall use its best efforts to make contracts with its employees pursuant to which any inventions relating or applicable to the production of carbide, cyanamid, ammonia, and nitric acid or ammonium nitrate made by such employees while in the service of the agent, shall be protected by United States patents, which patents shall become the property of the Air Nitrates Corporation, subject, however, to the condition that it shall grant to the United States at the time of issue of such patent or patents a nonexclusive license without royalty under each and all of them, such license to be restricted to the United States and to the purchasers of any or all of said plants who may receive a license under the provisions of Article X of the agreement of even date herewith between the American Cyanamid Co. and the United States. The term "employees" used in this paragraph shall not be deemed to include the persons described in paragraph No. 3 in Article X hereof.

ART. IX. *Subcontracts.*—The agent shall submit to the contracting officer for his written approval, in advance of its execution, any proposed subcontract as to which the contracting officer may direct in writing that his approval be first obtained.

All subcontracts shall contain a reference to this contract and an express provision that they are subject to all provisions hereof and that they may be assigned by the agent to the United States. Upon request in writing a copy of any subcontract shall be delivered to the contracting officer promptly upon the execution thereof.

ART. X. *Costs and expenses—Audit and payment thereof.*—The United States shall bear all costs and expenses of every character and description incurred or made in connection with the planning, construction, equipment, and operation of each of the said plants or any part thereof, and in the conduct of any other business or activities of the agent hereunder; and the United States shall supply all money necessary therefor in such amounts and in such manner as to permit all of the agent's activities with respect to the planning, construction, equipment, and operation of the plants to proceed without delays or interruptions and without the necessity of the agent providing any capital or borrowing any moneys. Vouchers for all accounts payable shall from time to time be furnished to the Chief of Ordnance, and upon presentation of satisfactory evidence he shall either furnish the agent funds to the amounts thereof, which funds shall be immediately paid out by the agent under the supervision of a representative of the Chief of Ordnance, or the vouchers may be paid direct by the Chief of Ordnance to the persons entitled to payment thereunder. Such vouchers shall be acted upon by the Chief of Ordnance promptly.

All accounts payable by the United States hereunder, including those in relation to costs and expenses of construction or operation, shall be subject to audit by the United States, which shall maintain at the plants and elsewhere, if necessary, a sufficient number of auditors promptly to audit the same.

To expedite payments to the agent the United States shall detail representatives at each of the said plants and at the agent's home office, with power and sufficient funds to discharge the pay rolls and to make any other payments as they shall become due hereunder. Payments by the United States shall be subject to correction for errors, if any.

The agent shall make no charge to the United States for the following things:

1. For procuring from the American Cyanamid Co. a license to it as agent of the United States to use the said company's patents and processes.

2. For procuring from the American Cyanamid Co. the disposal, for purposes of the Air Nitrates Corporation, of the said company's experiences, records, and plans appertaining to the production of the said chemicals hereinabove referred to.

3. For procuring from the American Cyanamid Co. the disposal, for the purposes of the Air Nitrates Corporation, of the following members of the said company's executive and technical force, namely: The president, vice president and general manager, sales and traffic manager, engineering assistant to general manager, superintendent of manufacture, chief technologist, chief engineer, assistant engineer, and in addition thereto, in connection with the operation of the said plants, two principal works managers, as such offices may from time to time be filled.

4. For procuring from the American Cyanamid Co. the disposal, for the purposes of the Air Nitrates Corporation, of all of the said company's plants for the purpose of training superintendents, foremen, and chief operatives.

ART. XI. *Agent's compensation.*—As full compensation for the services of the agent the United States shall pay to the agent the following fees:

1. *Construction fee.*—Three and one-third per cent of the cost in connection with the construction and equipment of the said plants, until such cost (exclusive of the agent's compensation) shall equal $30,000,000, and thereafter 1⅔ per cent of such cost in excess of said $30,000,000. Said fee shall be payable monthly upon that portion of the cost for which payment has been made during the month or months preceding and as to which the fee is unpaid. There shall be credited on account of said construction fee any payments for construction compensation heretofore made to the agent under the provisions of said contract of November 16, 1917. The total of the construction fee shall not exceed $1,500,000.

2. *Operation fee.*—One-quarter of 1 cent per pound of ammonium nitrate produced in compliance with Article VII hereof, and accepted or utilized by the United States, up to and including 110,000 tons produced in any fiscal year of the United States, and $0.00125 per pound of ammonium nitrate so produced and accepted or utilized in any said fiscal year in excess of such 110,000 tons. Payment shall be made monthly.

The Chief of Ordnance may direct the agent to produce at any one or more of said plants products other than ammonium nitrate, and to the extent that such products are not utilized in the making of ammonium nitrate in any of said plants operated by the agent, the agent shall receive as compensation for making such products an operation fee computed upon such a basis as will give the agent for making such products the same amount as the agent, by way of operation fee, would have received (1) where such products are nitrogenous compounds, for fixing an equivalent amount of nitrogen in the form of ammonium nitrate, and (2) where such products are other than nitrogenous compounds, for making ammonium nitrate equivalent in cost to that of such products.

ART. XII. *Basis of cost for construction fee.*—The cost upon which the construction fee of the agent is based shall be the entire cost of the construction of the plants herein mentioned, including, amongst other items, those mentioned in schedule A hereto annexed and made a part hereof. The enumeration of said items shall not be deemed to be inclusive of all items of cost and shall not be construed to exclude in determining cost and the fee thereon other items of expenditure entering into the cost of planning, constructing, and equipping the plants not therein enumerated.

ART. XIII. *Maintenance.*—The agent shall, at the expense of the United States, maintain the plants in suitable condition for economical operation, and to this end it shall make all proper repairs. The contracting officer may from time to time specify extraordinary repairs, which shall be made only with his written approval. Should any part of any plant be destroyed wholly or partly by fire or otherwise the Chief of Ordnance shall determine whether such part shall be restored.

ART. XIV. *Title to property.*—The title to all property, real or personal, paid for or partly paid for by the United States, shall, immediately upon such payment, or upon coming into the possession of the agent, vest forthwith in the United States.

ART. XV. *Records.*—The agent shall keep complete records as to all construction and operation expenses, all of which records shall at all times be open to the inspection of the duly authorized representatives of the United States.

Inspection.—The inspection officers of the Ordnance Department shall at all times have full access to the plants for the purpose of inspecting in every detail all work done, materials used, and ammonium nitrate produced, and becoming familiar with all processes and methods used in the manufacture thereof, and the agent shall afford them all necessary facilities and assistance for performing their duties aforesaid.

ART. XVI. *Loss and damage.*—The agent in operating, caring for, and storing property shall use all reasonable effort adequately to protect the same, but this shall not authorize or require the agent to take out or carry insurance for this purpose. The United States shall hold and save harmless the agent from all loss or damage (exclusive of future profits) by accident, fire, flood, explosion, or otherwise arising or growing out of the construction or operation of the said plants and all losses and expenses not compensated by insurance or otherwise.

ART. XVII. *Termination of agreement as to any plant.*—In the event that in the opinion f the Chief f Ordnance the public interests so require, this contract may be terminated as to any or all of the plants described herein by notice in writing to the agent without prejudice to any claim which either of the parties hereto may then have against the other. In the event of the termination of this contract as aforesaid the United States shall pay to the agent all costs and discharge all obligations of the agent arising in connection with the construction or operation of the said plant or plants theretofore properly incurred, but not previously paid or discharged, as to which said notice is given. At the option of the United States the agent shall assign or transfer to the United States all contracts outstanding at the date of termination as to any plant previously entered into by the agent hereunder in respect of such plant. In addition thereto the United States shall make the following payments under the following conditions:

(1) In the event that this contract is terminated as aforesaid as to any plant during the construction thereof, if the agent is not in default in any substantial agreement herein contained, the United States shall pay the agent such percentage of the construction fee provided for in Article XI hereof, and not theretofore paid, as may be found by the Chief of Ordnance as fairly and justly amounting to the percentage of the work then performed, including obligations incurred in respect to said plant, and for which payment has been or will be made.

(2) In the event that this contract is terminated as aforesaid as to any plant during or prior to the operation thereof by the agent, then the agent shall be paid the sum of money, if any, then due on account of the production of ammonium nitrate in said plant, and the United States shall thereafter continue to pay during the period set forth in Article IV hereof to the agent for the ammonium nitrate produced therein $0.0025 per pound for all ammonium nitrate produced in said plant in any fiscal year of the United States until such date in said year as the amount produced at said plant, together with that produced by the other plants referred to herein, shall equal 110,000 tons; and, as to the amount produced in said plant in said fiscal year, if any there be, after the said 110,000 tons of ammonium nitrate have been produced as aforesaid, the United States shall pay the agent $0.00125 per pound. The aggregate payments to the agent under this paragraph (2) on account of plants as to which this contract may have been terminated as aforesaid shall not exceed $550,000 in any said fiscal year. Wherever the designation ammonium nitrate is used in this paragraph (2), it shall be deemed to include other products, described in paragraph No. 2, in Article XI hereof, if any there be, produced in the plants described herein, but the fees due on said other products shall be calculated and determined according to the provisions of said paragraph (2) of Article XI hereof.

Provided, however, and it is understood and agreed, that this contract shall not be terminated as to any plant prior to June 1, 1921, or so long as the United States shall remain in the present war, except for the permanent cessation of all activities of the United States in connection with said plant, unless the agent exhibits such default or negligence as respects such plant as to require that the United States in its best interests should directly construct and operate said plant.

In the event of the termination of this contract as to any plant or plants aforesaid, the agent agrees to cooperate with the United States and to give to it its good offices and such assistance as the United States may from time to time request in making the planning, construction, equipment, and operation of such plants successful and economical in all respects.

ART. XVIII. *Right of United States to discontinue.*—Nothing in this contract contained shall be deemed to prevent the United States from at any time discontinuing the construction or operation of any or all of the said plants, and in the event of such discontinuance the United States shall be under no liability to the agent for any payments as respects such plant or plants beyond those in this agreement specified. In the event that construction or operation is resumed at any of said plants at which construction or operation has been discontinued, the provisions of this contract shall govern the rights and obligations of the parties with respect to any such plant to the same effect as though the construction or operation thereof had not been discontinued.

ART. XIX. *Sale of plants.*—If upon cessation of this war or for any other reason the United States determines to cease the construction, equipment, or operation of any of the said plants and to dispose of the same, the agent shall be given the first opportunity (for a reasonable period of time not to exceed six months after receipt of written notice stating the determination of the United States to dispose of the same, and the material terms upon which such disposition will be made), to purchase the same upon as favorable terms as the United States is willing to accept therefor, before the United States shall sell the same to any other party.

ART. XX. *Bond.*—The agent shall furnish to the United States within 20 days after the execution of this agreement a bond in the sum of five hundred thousand (500,000) dollars, conditioned upon the full and faithful performance by the agent of all terms, covenants, and conditions of that part of this agreement providing for the construction of said plants. The surety on said bond and the form thereof shall be satisfactory to the contracting officer. Unless such bond is furnished within said time limit this agreement may, at the option of the contracting officer, be canceled.

ART. XXI. *Contract nonassignable.*—This contract shall not, nor shall any right to receive payment or any other interest therein, be transferred or assigned by the agent to any person, firm, or corporation without the written consent of the Secretary of War.

Disputes.—Except as this contract shall otherwise provide any doubts or disputes which may arise as to the meaning of anything in this contract shall be referred to the Chief of Ordnance for determination. If, however, the agent shall feel aggrieved at any decision of the Chief of Ordnance upon such reference, he shall have the right to submit the same to the Secretary of War.

Persons not to benefit.—No Member of or Delegate to Congress or Resident Commissioner, nor any person belonging to or employed in the military service of the United States, is or shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom, but this article shall not apply to this contract so far as it may be within the operation or exception of section 116 of the act of Congress approved March 4, 1909 (35 Stats., 1109).

Prison labor.—No persons shall be employed in the performance of this contract who are undergoing sentences of imprisonment at hard labor which have been imposed by the courts of the several States, Territories, or municipalities having criminal jurisdiction.

ART. XXII. *Service of notices.*—Any notice addressed to the agent at 511 Fifth Avenue, New York, N. Y., or at such other address as the agent shall by notice in writing advise the contracting officer, and either there delivered or deposited in a postpaid wrapper in any post-office box regularly maintained by the United States, shall be deemed to have been served upon the agent. Nothing herein contained shall preclude service of notices upon the agent by delivery thereof to any of its corporate officers in person.

ART. XXIII. *Prior agreement superseded.*—This agreement shall supersede the agreement of November 16, 1917, between Air Nitrates Corporation and the

United States by which Air Nitrates Corporation is authorized to act as agent of the United States in the construction and operation of the Muscle Shoals plant hereinbefore referred to.

Provided, however, that such supersession shall not affect any of the rights or obligations of the parties hereto which have accrued or become fixed under said agreement of November 16, 1917, prior to the date hereof, except in so far as it is clearly intended by these presents that such rights or obligations shall be affected, whether through extinguishment, the substitution of others therefor, or otherwise.

Provided, also, that such supersession shall not in any way affect any of the subcontracts, obligations, or commitments which the Air Nitrates Corporation has heretofore in good faith entered into, made, or incurred under said agreement of the 16th of November, 1917.

ART. XXIV. *New contract for deficiency in appropriations.*—In the event that the existing appropriations applicable to the purposes of this agreement shall be inadequate, the United States shall have the right to execute and deliver, and the agent shall thereupon also execute and deliver, a new contract having the same terms and conditions as are contained herein.

ART. XXV. *Definitions.*—Wherever in this contract the words hereinafter enumerated are used they shall mean what is set opposite them:

Agent.—The party of the first part and its duly authorized representatives, successors, and assigns.

Chief of Ordnance.—The Chief of Ordnance, the Acting Chief of Ordnance, or any duly authorized representative of either.

Contracting officer.—The contracting officer executing this contract, his successor or successors, his or their duly authorized agent or agents, and anyone from time to time designated by the Chief of Ordnance to act as contracting officer.

Ton.—Two thousand (2,000) pounds.

Fiscal year of the United States.—The period from July 1 in any year to June 30 in the following year, both dates inclusive.

In witness whereof the parties hereto have caused these presents to be executed and delivered, in triplicate, at Washington, D. C., the day and year first above written.

AIR NITRATES CORPORATION,
By (Signed) FRANK S. WASHBURN,
President.
(Signed) A. E. BONN, *Secretary.*
UNITED STATES OF AMERICA,
By (Signed) SAMUEL MCROBERTS,
Colonel, Ordnance Department, National Army,
Contracting Officer.

Witnesses:
(Signed) M. G. LOGAN.
(Signed) C. LAVEGO COHEN.
(Signed) WILLIAM WILLIAMS.

SCHEDULE A.

ITEMS OF COST REFERRED TO IN ARTICLE XII.

(*a*) All the land, including gravel pits, quarries, and coal mines, labor, material, machinery, fixtures, equipment, apparatus, appurtenances, tools not owned by the workmen, supplies, and equipment necessary for either temporary or permanent used for the construction and operation of the plants, including the opening up and operation of gravel pits, quarries, and coal mines.

(*b*) Rental for construction plants and for the main and branch offices, and for furnishings and equipment for such offices.

(*c*) Loading and unloading construction plant, the transportation thereof, including transportation to and from the place or places where it is to be used in connection with said work, the installation and dismantling thereof and ordinary repairs and replacements during its use in the said work.

(*d*) Transportation and expenses, including transportation tax to and from the work of the necessary field and office forces, procuring labor, and expediting the production and transportation of material and equipment. All freight charges on equipment, furnishings, material, and supplies, including transportation tax thereon.

(*e*) Salaries of managers, engineers, superintendents, timekeepers, accountants, clerks, foremen, and other employees at the main and field offices of the agent in connection with said work, salaries of the executive officers of the agent except such as shall be placed at the disposal of the agent by the American Cyanamid Co. and set forth in said contract marked Exhibit 1.

(*f*) Buildings, houses, warehouses, hospitals, infirmaries, stores, commissaries, and structures, and the equipment required therefor and furnishings and equipment required for main and field offices, and the cost of maintaining and operating the same, and including such minor expenses as telegrams, telephone service, expressage, postage, etc.

(*g*) Buildings of different grades, warehouses, local power plant, structures, plant machinery, railway and trolley tracks, locomotives, cars, roundhouses, roadways, grading and sewerage, water and lighting systems, and fixtures.

(*h*) All bonds required by this agreement and all bonds necessary or proper, fire, liability, and other insurance, and all losses and expenses not compensated by insurance which have been actually sustained by the agent in connection with said work. Such losses and expenses, when incurred by the agent in connection with damage to third persons resulting from the work or due to the agent's fault or neglect, shall be included in the cost of the work, but not for the purpose of determining the agent's fee; but such losses and expenses when incurred by the agent in connection with constructing and replacing any of the work destroyed or damaged shall be included in the cost of the work for all purposes hereunder.

(*i*) Permit fees, royalties, and other similar items of expense incidental to the execution of this agreement.

(*j*) Transportation, including all transportation tax, traveling and hotel expenses, and telephone, telegraph, mail, and express, expenses of officers, engineers, and other employees of the agent as are actually incurred in connection with this work.

(*k*) Amounts paid to contractors or subcontractors and sums paid by the United States upon contracts made with any person at the request of the agent, and the cost of all materials furnished by the United States.

(*l*) All manner of expense of the agent in creating and constructing the plants and their equipment, including administration, superintendence, engineering, materials, labor, freight, transportation tax, power, heat, light, rentals, insurance, liabilities, losses not covered by insurance, and all overhead, general, and legal cost and expense, and including all other items of expenditure made by the agent not properly chargeable to manufacturing.

(*m*) In addition thereto further allowances, if any there be, of cost as from time to time may be made by the contracting officer.

EXHIBIT I.

(LICENSE AGREEMENT.)

This agreement entered into this 8th day of June, 1918, between American Cyanamid Co., a corporation organized and existing under and pursuant to the laws of the State of Maine, of the first part, hereinafter called the licensor, and the United States of America, hereinafter called the licensee, by Samuel McRoberts, colonel, Ordnance Department, National Army, hereinafter called the contracting officer, acting by and under the authority of the Chief of Ordnance, United States Army, and under the direction of the Secretary of War, of the second part.

Witnesseth:

Whereas the licensee has entered into an agreement of even date herewith with Air Nitrates Corporation, a corporation organized and existing under and pursuant to the laws of the State of New York, by which agreement said corporation has agreed as agent of the licensee to construct and operate for the licensee plants for the manufacture of ammonium nitrate, all for the reasons and as is more particularly set forth in said agreement; and

Whereas the licensor possesses certain United States letters patent and is the owner of exclusive licenses under certain other letters patent of the United States, all as set forth in Schedule A hereto annexed and made a part hereof, covering certain processes and methods involved in the manufacture of lime nitrogen (calcium cyanamid), its conversion to ammonia gas and the oxidation of ammonia to weak nitric acid, and may grant licenses thereunder; and

Whereas the licensor, to enable said Air Nitrates Corporation to carry out said agreement, will place at the disposal of said corporation its experiences, studies, records, designs, plans, and certain of its executive and technical force, all as hereafter set forth; and

Whereas the licensor entered into a contract with the licensee under date of November 16, 1917, which contract was executed on behalf of the licensee by J. W. Joyes, colonel, Ordnance Department, United States Army, contracting officer, with respect to the license hereinafter granted:

Now, therefore, in consideration of the mutual agreements herein contained, the said parties have agreed, and by these presents do agree, to and with each other as follows, to wit:

ARTICLE I. *License to use certain patented processes, etc.*—The licensor for use and application exclusively by the United States Government or the aforesaid agent at said plants, has given, granted, assigned, and does hereby give, grant, and assign to the licensee the right, license, and privilege to use any and all of the processes, methods, and designs covered by letters patent of the United States and involved in the manufacture of lime nitrogen (calcium cyanamid), its conversion to ammonia gas and the oxidation of the ammonia to weak nitric acid, which said letters patent are described in Schedule A, annexed hereto and made a part hereof, for and during the time the United States shall remain in the present war, and in any event until June 1, 1921, together with all improvements therein and all patents or other rights relating thereto which the licensor may hereafter make or secure during said period.

The licensor agrees that nothing contained in this agreement shall restrict the licensee to the use only of such rights and patents, as the licensor now possesses or may hereafter possess, and the licensee has the privilege of using the processes, rights, and patents of persons other than the licensor, either in conjunction with the processes, rights, and patents of the licensor or independent thereof, if in the judgment of the contracting officer such action is required to obtain the best results of operation.

ART. II. *Use of licensor's experiences, records, etc.*—The licensor agrees to place at the disposal of the said Air Nitrates Corporation and the contracting officer, for the production of ammonium nitrate and the construction and operation of the plants referred to in the agreement between the licensee and the Air Nitrates Corporation above referred to, all the experiences, records, studies, designs, and plans of the licensor bearing on and pertaining to the processes necessary or incidental to the manufacture of ammonium nitrate now owned by the licensor and agrees that the said Air Nitrates Corporation and its representatives and the contracting officer shall have access to said experiences, records, studies, designs, and plans at all reasonable hours, and shall be permitted to make copies thereof and excerpts therefrom. The licensor further agrees to divulge to the said Air Nitrates Corporation and the contracting officer for the sole purpose of this agreement and said agreement between Air Nitrates Corporation and said licensee, all of the secret processes which, combined with the processes covered by the aforesaid letters patent, go to make up the system of manufacture of ammonium nitrate.

ART. III. *Use of licensor's plants for training purposes.*—The licensor agrees to place at the disposal of the said Air Nitrates Corporation and the contracting officer all of the plants now owned or operated by the licensor for the purpose of training of superintendents, foremen, chief operatives, and the like for the proposed plants to be constructed and operated by the Air Nitrates Corporation, and further agrees that the said corporation and its representatives and the contracting officer shall have access to said plants at all reasonable hours for the purpose above referred to.

ART. IV. *Services of certain of licensor's technical men.*—The licensor agrees to place at the disposal of the said Air Nitrates Corporation for the construction and operation of the plants under the contract above referred to the following members of the executive and technical forces of the licensor as from time to time constituted, namely, president, vice president and general manager, engineering assistant to general manager, superintendent of manufacturing, sales and traffic manager, chief technologist, chief engineer, assistant engineer, and, in addition thereto, in connection with the operation of said plants, two principal works managers; and further agrees to pay the entire salaries of such persons during the terms of said agreement between the licensee and said corporation, and agrees that at all times it will maintain an executive and technical force which shall be familiar with the operation of the processes involved in the manufacture of ammonium nitrate.

ART. V. *Benefit hereunder to accrue to Air Nitrates Corporation.*—The licensor agrees that all of the benefits to accrue to the licensee by the terms of this agreement may be at any time assigned to the Air Nitrates Corporation and shall in any event accrue to the Air Nitrates Corporation, but only for the purposes of said agreement between the United States and the Air Nitrates Corporation. The licensor shall have the right to grant, and at the written request of the licensee will grant, a license in all respects similar to the license herein granted to the Air Nitrates Corporation to enable said corporation to carry out its agreement with the United States of even date herewith.

ART. VI. *Royalty.*—In consideration of the granting of the license provided for in Article I hereof and of the other conditions to be performed by the licensor, the licensee agrees to pay the licensor during the term thereof specified in said article, as royalty, an amount equivalent to six mills ($0.006) per pound of all nitrogen fixed as lime nitrogen manufactured at the plants hereinbefore described in the contract of even date herewith between the United States and the Air Nitrates Corporation, and to which reference has hereinbefore been made, up to and including the first ninety-one million seven hundred thousand (91,700,000) pounds of such nitrogen so fixed in any fiscal year of the United States, and in addition thereto three mills ($0.003) per pound of all nitrogen fixed as lime nitrogen in any said fiscal year in excess of the said ninety-one million seven hundred thousand (91,700,000) pounds of nitrogen, it being further understood and agreed that no part of such royalty shall directly or indirectly inure to the benefit of an alien enemy of the United States except as may appear upon a disclosure of stock lists made pursuant to law. Payment for royalties shall be made each month as early in the month as practicable upon the presentation of satisfactory evidence showing the production during the preceding month of nitrogen fixed as lime nitrogen at the plants hereinbefore referred to.

ART. VII. *Acknowledgment of ownership of patents, processes, etc.*—It is understood and agreed that so far as the right, license, and privilege to use any and all of the patents, processes, methods, and designs, as described in Schedule A hereto annexed, is given, granted, and assigned hereby, the Government and its agents and other parties claiming under this license, do and they shall acknowledge and recognize the American Cyanamid Co. as the sole owner of said patents, processes, methods, and designs and of the exclusive right to use the same, subject only to the rights granted to the United States by this license and any license granted said Air Nitrates Corporation, and the United States shall, so far as practicable, exclude the public from all works in which said processes shall be employed, and generally shall use all reasonable means to preserve said rights unimpaired.

ART. VIII. *Indemnity against infringement.*—To the extent only that the licensor shall have received cash hereunder the licensor agrees to defend and save harmless the Air Nitrates Corporation and the United States from all suits and claims for infringement by reason of the use by either of them of its patents for the making of cyanamid and the making of ammonia gas, which said patents are described in Schedule B hereto annexed and made a part hereof, and pay any judgments which may be obtained therefor against the licensee or the said Air Nitrates Corporation, but only to the extent aforesaid.

The licensor will defend and same harmless the licensee and the air Nitrates Corporation from any action or suit brought by any person in privity with it in which the right of said licensee or said corporation to use said patents described in said Schedule A shall be attacked: *Provided, however,* That the United States shall promptly give the licensor written notice of any and all such suits, actions, or claims described in this article, and tender the defense thereof to the licensor.

ART. IX. *Termination of agreement as to any plant.*—In the event that the United States shall terminate this agreement as to any one or more of the plants to be constructed by the Air Nitrates Corporation under said agreement of even date herewith and pursuant to the provisions in that behalf therein contained, all of the rights and privileges herein inuring to the said Air Nitrates Corporation shall inure in respect of the plant or plants as to which said agreement is terminated. to the benefit of the United States, but only until June 1, 1921, and so long thereafter as the United States shall remain in the present war.

ART. X. *License to use patents, processes, etc., after 1921 or the end of the war; arbitration of royalties thereunder.*—The licensor hereby gives and grants to the licensee, in addition, for use and application exclusively by the licensee in the operation of the aforesaid plants, the right, license, and privilege to use any and all of the patents, processes, methods, and designs embraced in the license hereinbefore granted to the licensee by Article I hereof, from and after the 1st day of June, 1921, or the date upon which the United States shall cease to be in the present war (whichever date shall last occur) and until the expiration of the United States patents covering the same, upon the following terms, to wit:

The licensee shall pay monthly to the licensor for such additional license under this article a royalty, unless and until changed by the arbitration hereinafter provided, of 1½ cents per pound of nitrogen content in any and all products manufactured by the licensee at each and every of said plants under and by the use of any of the patents, processes, methods, or designs embraced in the said additional license.

In the event that either the licensor or the licensee shall be dissatisfied with the aforesaid royalty in this article defined, either or both may, within the first three years of the period fixed for the duration of said additional license, demand that the amount of the royalty to be paid hereunder shall be determined and fixed by arbitration. Such demand shall be made in writing and shall be delivered to the other party hereto, together with the name and address of the arbitrator chosen by the party demanding the arbitration and the other party hereto shall, within 15 days thereafter, choose a second arbitrator and notify the party demanding the arbitration of its choice and give the name and address of such arbitrator. The two arbitrators so chosen shall, within 15 days after being notified by either party that the second arbitrator has been chosen, choose a third arbitrator. The arbitrators, when chosen, shall promptly fix a time and place for the hearing, and then and there the parties hereto shall attend and present their respective proofs and arguments. The hearing may from time to time be adjourned by the arbitrators by a writing notifying the parties of the time and place to which such adjournment is made.

The arbitrators shall with all reasonable speed ascertain and determine what, in their opinion, under all the circumstances, are adequate and reasonable royalties to be paid under this article and the date, not earlier than that of the demand for such arbitration, from which the said award shall be effective. They shall notify the parties in writing of the royalties so ascertained and determined and state the amount, if any, that either party may then owe to the other with respect to royalties under the terms of the award. The said award when signed by any two of the arbitrators shall be final and conclusive upon all parties concerned.

In the event that either the second or the third arbitrator shall not be chosen in the manner and within the time herein above fixed, any United States district judge for the southern district of the State of New York, upon the application of either party, may choose an arbitrator or arbitrators, as the case may be, to act.

No terms with respect to royalty contained in this agreement or in the said agreement of November 16, 1917, or in any agreement between said Air Nitrates Corporation and the United States, or in any negotiations or proposals between the said several parties looking to the making of the said agreements or relating to the subject matter thereof shall be utilized by either party in said arbitration or taken into consideration by the arbitrators in making their award.

The costs and expenses of the arbitrators and of the arbitration shall be ascertained by the arbitrators and shall be borne equally by the parties hereto.

The licensee may transfer to the purchaser of any one or more of said plants the right to avail itself of the license in this article granted in the operation of the plant or plants so purchased, if said purchaser, as a term of said purchase, expressly covenants to undertake, observe, and perform all the terms of this article, including the payment of royalties and the findings of the said arbitrators, if any, as respects the plant or plants so purchased.

ART. XI. *Cessation of royalties.*—If the use of the inventions of the aforesaid letters patent and the methods, apparatus, and processes owned by the licensor and disclosed hereunder to the Air Nitrates Corporation and the licensee shall be discontinued by the Air Nitrates Corporation or by the licensee or its assigns, the obligation for the payment of royalties hereunder shall cease as to those of said parties who shall have so discontinued such use.

ART. XII. *Contract not assignable.*—This contract shall not, nor shall any right to receive payment, or any other interest herein, be transferred or assigned by the licensor to any persons, firms, or corporations.

ART. XIII. *Persons not to benefit.*—No Member of or Delegate to Congress or Resident Commissioner is, or shall be, admitted to any share or part of this contract, or to any benefit that may arise therefrom, but this article shall not apply to this contract so far as it may be within the operation or exception of section 116 of the act of Congress approved March 4, 1909 (35 Stat., 1109).

ART. XIV. *Disputes.*—Except as this contract shall otherwise provide, any doubts or disputes which may arise as to the meaning of anything in this contract shall be referred to the Chief of Ordnance for determination. If, however, the licensor shall feel aggrieved at any decision of the Chief of Ordnance upon such reference, he shall have the right to submit the same to the Secretary of War.

ART. XV. *Definitions.*—Whenever in this contract the words hereinafter enumerated are used they shall mean what is set opposite them:

Licensor.—The party of the first part and its legal representatives, successors, and assigns.

Chief of Ordnance.—The Chief of Ordnance, the Acting Chief of Ordnance, or any duly authorized representative of either.

Contracting officer.—The contracting officer executing this contract, his successor or successors, his or their duly authorized agent or agents, and anyone from time to time designated by the Chief of Ordnance to act as contracting officer.

ART. XVI. *New contract for deficiency in appropriations.*—This agreement shall be binding upon the licensor for the term of the license, but in the event of the existing appropriations applicable to the purposes of this contract being inadequate, the licensee shall have the right to execute and deliver, and the licensor shall thereupon also execute and deliver, a new contract having the same terms and conditions as are contained herein.

ART. XVII. *Previous agreement superseded.*—This agreement shall supersede the said agreement of November 16, 1917, between the licensor and the licensee.

In witness whereof, the parties hereto have caused this contract to be executed in triplicate, at Washington, D. C., the day and year first above written.

AMERICAN CYANAMID CO.,
Licensor.
By FRANK S. WASHBURN,
President.

Attest:
C. M. GRANT, *Secretary.*

UNITED STATES OF AMERICA,
By SAMUEL MCROBERTS,
Colonel, Ordnance Department, N. A.,
Contracting Officer.

Witnesses:
M. G. LOGAN.
E. J. PRANKE.
WILLIAM WILLIAMS.

SCHEDULE A.

[Being a part of license agreement hereto annexed.]

LIST OF PATENTS COVERING PROCESSES AND PRODUCTS OF THE PROPOSED GOVERNMENT NITRATE PLANTS.

United States patent 776314, "Process of making ammonia," November 29, 1904.

United States patent 785161, "Process of making nitrogen compounds," March 21, 1905.

United States patent 12762, "Process of making nitrogen compounds," March 10, 1908.

United States patent 996011, "Method of making nitrogen compounds," June 20, 1911.

United States patent 999071, "Apparatus for producing calcium cyanamid," July 25, 1911.

United States patent 1009705, "Process of making calcium cyanamid," November 21, 1911.

United States patent 987674, "Process of producing nitrogen compounds," March 21, 1911.

United States patent 1006927, "Method of producing nitrogen compounds from carbids," October 24, 1911.

United States patent 1010404, "Apparatus for producing nitrogen compounds from carbids," November 28, 1911.

United States patent 1100582, "Process of crushing and grinding calcium carbid," June 16, 1914.

United States patent 1100539, "Syclical process of fixing atmospheric nitrogen," June 16, 1914.

United States patent 1103060, "Method and means for fixing nitrogen," July 14, 1914.

United States patent 1103061, "Process and apparatus for fixing atmospheric nitrogen," July 14, 1914.

United States patent 1103062, "Method of and apparatus for fixing nitrogen," July 14, 1914.

United States patent 1149653, "Process of making ammonia from calcium cyanamid," August 10, 1915.

United States patent 1183885, "Apparatus for producing ammonia," May 23, 1916.

United States patent 1154640, "Process of producing ammonia," September 28, 1915.

United States patent 1163095, "Process of making ammonia from calcium cyanamid," December 7, 1915.

United States patent 1242953, "Process for producing nitrose gases," October 16, 1917.

United States patent 1193796, "Method of oxidizing ammonia," August 8, 1916.

United States patent 1193797, "Process of and apparatus for oxidizing ammonia," August 8, 1916.

United States patent 1193798, "Catalyzer apparatus for oxidizing ammonia," August 8, 1916.

United States patent 1193799, "Platinum catalyzer," August 8, 1916.

United States patent 1193800, "Catalyzer for oxidizing ammonia," August 8, 1916.

United States patent 1206062, "Process of making nitric acid and other products," November 28, 1916.

United States patent 1217247, "Process of making ammonia nitrate and other products," February 27, 1917.

United States patent 1206063, "Process of making nitric acid and other products," November 28, 1916.

SCHEDULE B.

[Being a part of license agreement hereto annexed.]

United States patent 776314, "Process of making ammonia," November 29, 1904.

United States patent 785161, "Process of making nitrogen compounds," March 21, 1905.

United States reissue 12762, "Process of making nitrogen compounds," March 10, 1908.

United States patent 996011, "Method of making nitrogen compounds," June 20, 1911.

United States patent 999071, "Apparatus for producing calcium cyanamid," July 25, 1911.

United States patent 1009705, "Process of making calcium cyanamid," November 21, 1911.

United States patent 987674, "Process of producing nitrogen compounds," March 21, 1911.

United States patent 1006927, "Method of producing nitrogen compounds from carbids," October 24, 1911.

United States patent 1010404, "Apparatus for producing nitrogen compounds from carbids," November 28, 1911.

United States patent 1100582, "Process of crushing and grinding calcium carbid," June 16, 1914.

United States patent 1100539, "Cyclical process of fixing atmospheric nitrogen," June 16, 1914.

United States patent 1103060, "Method and means for fixing nitrogen," July 14, 1914.

United States patent 1103061, "Process and apparatus for fixing atmospheric nitrogen," July 14, 1914.

United States patent 1103062, "Method of and apparatus for fixing nitrogen," July 14, 1914.

United States patent 1149653, "Process of making ammonia from calcium cyanamid," August 10, 1915.

United States patent 1183885, "Apparatus for producing ammonia," May 23, 1916.

United States patent 1154640, "Process of producing ammonia," September 28, 1915.

United States patent 1163095, "Process of making ammonia from calcium cyanamid," December 7, 1915.

Col. BURNS. I think that is all, except that Mr. Washburn gave a solution of this problem which consisted in stopping the power development on the Tennessee River, the placing of the plant in a stand-by condition for an undetermined period until the future might find a place for it. The Secretary of War has covered the logic of stopping that power plant, and we were discussing the logic of putting that plant in stand-by just before adjournment this noon, and it seems to me that that is pretty much out of the question, because what the Government wants in this particular case is real nitrogen preparedness, from a military standpoint, and we certainly would not get any such preparedness if we did not have an operating plant and a going organization; and Mr. Washburn, I think, has very convincingly proved the opposite of his contention in his statement which I read to you this morning, which he made before Congress in 1916. Some of the Senators were not here when I read it, but I do not think it necessary to reread that, because it will be put in the record and available there for reading. However, that very strongly indicates that it would be a very unwise policy for the United States to pursue, at least he said so in 1916.

The CHAIRMAN. I have refrained from asking any of those who have testified here to have nothing printed except what they read, because I did not know whether the department, and also Mr. Washburn, cared to have the correspondence and other things published or not. I can see where, during the war, there might have been correspondence passing between one or the other of the parties which perhaps ought not be made public, and that is the reason why I have not asked you to print the letters.

Col. BURNS. The particular subject that I was talking about then——

The CHAIRMAN (interposing). Anything that you wish to put in, that the War Department and also Mr. Washburn desire to make public, of course, I am sure the committee will be glad to have printed.

Col. BURNS. Senator, this statement I just spoke of was a statement that was made by Mr. Washburn before the Committee on Military Affairs of the House in 1916, and is already a public document. I read it this morning, and do not think it necessary to read it again.

The CHAIRMAN. If you read it, of course it will be printed and be a part of the record.

Col. BURNS. If I might conclude by reading an extract from the report of Gen. Pershing to the Secretary of War under date of

March 23 of this year—he examined this plant in December of last year [reading]:

GENERAL HEADQUARTERS,
AMERICAN EXPEDITIONARY FORCES,
March 29, 1920.

Extract from Gen. Pershing's report of March 23 to Secretary of War:

* * * *Muscle Shoals nitrate plant.*—In the Muscle Shoals nitrate plant the Government has a permanent installation which is of the greatest importance. In another war a plant assuring a domestic supply of nitrogen might well be a decisive factor in maintaining our security. It is understood that this plant can be utilized in peace for the commercial manufacture of nitrogen products and that such use would return a reasonable profit on the investment represented by the plant while maintaining it constantly available for military purposes. * * *

The CHAIRMAN. Are there any questions which the committee wishes to ask Col. Burns? [After a pause.] If there is nothing further, Col. Burns, we are much obliged to you.

Col. BURNS. I think that finishes our statement of the case.

The CHAIRMAN. Very well. Are you ready to proceed this afternoon, Mr. Washburn, or do you desire to wait until to-morrow?

Mr. WASHBURN. I think it would be better to wait, Mr. Chairman. The haphazard presentation of anything here to the committee is not going to inform you as to our point of view or enable you to judge of our point of view as well as for us to take it up in a systematic manner. Generally, it is not as easy for us to prepare for a hearing as it is for some of the gentlemen at least who have represented the Government in its contention, because of the very fundamentally different line of approach to the problem as between a Government and a concern representing an industry. The commercial and industrial approach to it must be a quantative one, based upon markets and prices and exact data. A number of questions were raised here yesterday and to-day which require of us, in order to properly comment upon them, the gathering of some exact figures and statements and things of that sort. So that we are not prepared now to do the subject justice; we would not be prepared to-morrow morning.

The CHAIRMAN. When do you think you could be ready?

Mr. WASHBURN. To-day is Wednesday—I should think we would be prepared by Friday morning.

The CHAIRMAN. Would that be satisfactory to the committee?

Senator SMITH of South Carolina. Mr. Chairman, I would like very much, without doing any injustice to Mr. Washburn——

Senator RANSDELL (interposing). That is just one day more.

Senator SMITH of South Carolina. Might I ask you, Mr. Washburn, if you think you could present your case on Friday?

Mr. WASHBURN. Yes.

Senator SMITH of South Carolina. Complete?

Mr. WASHBURN. Complete, so far as giving the case; it might be we would want to insert some data or something of that kind which would be coming along two or three days later; but substantially, so far as your understanding our point of view is concerned, we can give it on Friday.

Senator SMITH of South Carolina. I would have no objection, Mr. Chairman.

The CHAIRMAN. If there is no objection——

Senator RANSDELL (interposing). May I ask, Mr. Chairman, if that will complete the hearing when we shall have heard Mr. Washburn?

The CHAIRMAN. So far as I know, I hope we will be able to complete the hearing.

Senator RANSDELL. And there will be nothing in the way of rebuttal to his testimony, so far as you know?

The CHAIRMAN. So far as I know, there will be none.

(At this point the committee conferred among themselves, of which no record was made.)

Mr. WASHBURN. May I interrupt you, Mr. Chairman, just a moment?

The CHAIRMAN. Certainly.

Mr. WASHBURN. Possibly something I may say to you that may have a bearing upon what the committee is considering now. I think I was overpersuaded as to the time in which we can prepare ourselves. In thinking it over I am quite confident that we can not be ready before Saturday morning, but we can be ready and will be ready on Saturday morning. I would appreciate it very much if that change could be made, when I realize that there is only one day to prepare. If I come on Friday, that merely means we can not get ready.

The CHAIRMAN. Then the committee will stand adjourned to meet next Tuesday at 10.30 o'clock a. m.

Mr. WASHBURN. I want to thank you for your courtesy, Mr. Chairman, and also thank the other gentlemen of the committee.

The CHAIRMAN. We thank you, gentlemen, for the information that you have given us.

(Thereupon, at 4.30 o'clock p. m., the committee adjourned, to meet Tuesday, April 27, 1920, at 10.30 o'clock a. m.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

TUESDAY, APRIL 27, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

Pursuant to adjournment, the committee met at 10.30 o'clock a. m. in Room 326, Senate Office Building, Senator Asle J. Gronna presiding.

Present: Senators Gronna (chairman), McNary, Kendrick, and Ransdell.

The Chairman. The committee will come to order. We meet again this morning to consider Senate bill 3390, providing for the production of atmospheric nitrogen, and Mr. Washburn has indicated his willingness to make a statement. I suppose it will be what I might call in rebuttal of the testimony given by the experts of the War Department. Mr. Washburn, you may proceed in your own way.

STATEMENT OF MR. FRANK S. WASHBURN, PRESIDENT OF THE AMERICAN CYANAMID CO., 511 FIFTH AVENUE, NEW YORK CITY—Resumed.

Mr. Washburn. Mr. Chairman and gentlemen of the committee, there are two matters that might be termed questions of personal privilege that I would like to deal with first. I think neither one of them is a determining factor in this situation by any means, but I think it quite important that I should clear up two inferences that might be drawn from the testimony given last by administration representatives before your committee. One has to do with the relationship of the American Cyanamid Co. to the four steps that comprise the whole method of manufacture at Muscle Shoals; and the other has to do with the question as to whether we expected or demanded a profit as such out of our war work.

I hesitate to take very much time with either one of these questions as I fear to do so might bore you; and, as I have said, neither one of these questions is vital to the situation under consideration by your committee. One of the Government's witnesses at your hearing on the 20th of April analyzed what might be called the degree of importance of the American Cyanamid Co. to the situation which confronted the Government at the time the company was asked by the Government to build the Muscle Shoals plant for the production of ammonium nitrate. He said there are four essential steps in the process: (1) The manufacture of lime of nitrogen (cyanamid), which he said was strictly and solely one which the cyanamid company controlled, as well as had experience in; (2) that the second process for the transformation of lime nitrogen into ammonia was one in which the cyanamid company had had some experience, although they could not be said to control it in full; (3) that the third process, which is the oxidation of ammonia to nitric acid, was one in which they had had some experience, although could not be said to have control of the process; and (4) that the fourth and final process, which was the bringing together of a certain part of the ammonia and the nitric acid, was neither controlled nor was it a matter in which the company had had experience.

In support of this point of view as to the limited relationship of the company to various steps in the manufacture of ammonium nitrate, the witness stated, with reference to the conversion of lime nitrogen to ammonia, that while the conversion of lime nitrogen to ammonia was principally practiced by the American Cyanamid Co., it was also done by the Du Pont Co. and some others.

The fact is that the American Cyanamid Co. at the time it undertook this work for the Government had been operating for a considerable period the largest single plant in the world for the transformation of lime nitrogen into ammonia. The only other plants on this side of the Atlantic Ocean were built by the American Cyanamid Co.; placed in initial operation by the staff of that company; and placed at the disposal of the companies which used them under a contract by which they were obliged to purchase all of the lime nitrogen used in these plants from the American Cyanamid Co., and under the further obligation that whenever they should cease to buy raw material from that company, they should cease the use of the plants and turn them back to the American Cyanamid Co. In other words, our experience in and control of the second step was just as great as our experience in and control of the first step; and I am quite confident that the Government representative in expressing his opinion somewhat to the contrary did it through lack of knowledge of the relations between our company and these other companies which used this process.

As to the third step, namely, the oxidation of ammonia to nitric acid, this was practiced by the American Cyanamid Co. at its plant in New Jersey under exclusive patents owned by it. The art was not practiced elsewhere on this side of the Atlantic. While the capacity of the company's plant was small, the units employed in that plant were of the same size as were later installed in greater number at Muscle Shoals, and which were eminently successful there. The company possessed, as far as was known at the time, the only successful method of oxidizing cyanamid ammonia to nitric acid. The Ostwald process, the patents of which were owned by the English Cyanamid Co., had proved, as one of the other witnesses before you testified, unsuccessful in commercial application. The process of the American Cyanamid Co. was essentially the same as that so successfully employed in Germany during the war in the manufacture of nitrate nitrogen, but we believe an improvement thereon.

There was still a third, but experimental and unperfected, process known in this country which was believed to have merit and which we were strongly urged by certain Government commissions to install in place of our own. Notwithstanding every effort on the part of the Government to develop this process during the war, it was not brought to a workable state. Shortly before the signing of the armistice a sample apparatus was turned over to us at Muscle Shoals with the request that we should endeavor to develop it into a practicable process.

Senator **Ransdell.** What was the name of that process?

Mr. **Washburn.** I do not know that it has a name. I will ask some one here with me if you wish.

Senator **Ransdell.** Never mind. Was that a process they were trying to work out at plant No. 1?

Mr. **Washburn.** Yes; that was a part of the process they were endeavoring to work out at plant No. 1.

The fourth step was one in which we had had no experience whatsoever, but the recommendations and advice which we received from those who manufactured ammonium nitrate by the usual methods and the usual materials proved to be wholly impracticable, while our own process, as devised by the research department of the American Cyanamid Co., proved from the first to be entirely successful and gave, as you know, a product superior in quality to any which the Government received from other sources, and superior to the specifications for the material given us by the Ordnance Department.

In short, I think that our contribution was of equal importance in each of the four steps involved in the manufacture of ammonium nitrate from atmospheric nitrogen.

Now, gentlemen of the committee, the other minor consideration to which I have referred is the matter of compensation to the American Cyanamid Co. There was read to you by one of the Government representatives extracts from certain letters addressed by the American Cyanamid Co. to the Government during the period of negotiations relative to the construction and operation of the nitrate plants. They were read for the purpose of indicating that the company wished an unreasonable compensation for its war work as distinguished from an effective protection from the destructive competitive effects of these plants should they be placed in commercial operation after the war.

As I have already told you the one serious question at issue between the Government and the company in those negotiations was the matter of protection of the company from what one of the principal advisers of the Government at that time designated as "A monster which would thus be reared by the United States Government for the devouring of the American Cyanamid Co."

The letters, arguments, and exchanges of views that came to the surface, were all expressions of an effort to commute in terms which should be adopted eventually as the best protection for the company practicable of accomplishment.

The company's offer in more than one meeting with the Chief of Ordnance and the War Industries Board was to undertake the work desired by the Government without any compensation whatsoever, except the payment of bare expenses, providing the Government would bind itself to pay a royalty on the commercial product at a figure which was tentatively fixed at 40 cents per unit of ammonia, substantially equivalent to $11 per ton of lime nitrogen.

The opinion of the Government attorneys, which opinion at that time was coincided in by our own attorneys, was that no such protection could be legally given by the Government; and if placed in the contract would be extralegal, and therefore not capable of being carried into effect.

May I ask that you place yourselves in our position and assume, if you choose, that you are contemplating an investment under these conditions in the stock of the American Cyanamid Co.? Here was a plant to be constructed which had a capacity for the production of nitrogen by the cyanamid process equivalent to four times the capacity of the company to produce and about six times what the markets at that time under peace conditions would absorb. Had you been informed that the cyanamid company was expecting to build such a plant what would you have devised as a means of protecting the company against its future commercial operation, possibly in the hands of the Government, whose purpose would be to sell substantially without profit, and which in any event does not include in its costs of merchandising and manufacturing interest, amortization, obsolescence, depreciation, local and State taxes, Federal taxes, insurance, legal expense, and advertising?

You must appreciate what the effects upon the American Cyanamid Co. would be to dump upon the American market four times as much nitrogen as it could produce in its own plants and under conditions in which the object is not commercial gain on the part of the competitor, who is relieved from costs the combined amount of which is far greater than any profit which normally accrues to the industry. How would you have gone at it? Try as we would on both sides, we were unable to accomplish the result. The only thing in which even partial protection to the company could be commuted was a monetary return to the company and a small and uncertain royalty. These, in the nature of things, were bound to be wholly inadequate, and, furthermore, very uncertain of application in the final analysis.

And what was the result? It was an agreement under which the American Cyanamid Co. was to receive as a fee for designing, planning, and constructing the plant a maximum under any circumstances of $1,000,000. It was wholly improbable—in fact, impossible—that the net return to the company should even approximate this amount, for out of it must come salaries paid to those of the staff of the American Cyanamid Co. who were assigned to carrying on the Government's work, practically to the exclusion of everything else, and whose salaries for this period amounted to over $200,000. It was impossible in the nature of things and is the experience of practically every contractor who undertook construction work for the Government that all the expenditures of the company would be borne by the Government, notwithstanding this agreement that it would do so. It was not reasonable to expect, and it was not in accordance with anyone's experience that millions of dollars' worth of work could be done for the Government and there be no items, however carefully matters were handled, which the Government would decline to pay.

Then there was the inevitably large Federal war tax which apply to the remainder, whatever that remainder might be. The operating and royalty fees which were to be paid the company in addition to its construction fee just referred to were problematical and dependent upon the continuance of the war—and, as it proved, amounted in total sum, as far as I recall at the most, to about $15,000. Then there was the final understanding that if the plant should be used for commercial uses the American Cyanamid Co. should have adequate compensation. This was thrown in as a forlorn hope, and, as you know, was eventually stricken out in a substitute contract made at the time when the Government asked us to undertake the construction and operation of two additional plants.

I very much doubt whether any of you gentlemen would have invested in the stock of the American Cyanamid Co. under these circumstances and conditions.

The CHAIRMAN. The compensation you are speaking of has reference to a royalty on what?

Mr. WASHBURN. A construction fee and a royalty for operation.

The CHAIRMAN. You are speaking of both?

Mr. WASHBURN. Yes, sir. The committee has expressed much interest in some of the tentative proposals which came to the surface during this period of negotiations just referred to and which provided for the company's ownership of a part of the plant after the close of the war. This, I think, all will agree, was the only possible adequate measure of protection to the American Cyanamid Co. But it was politically unsound. And wherever I use the word "politically" I use it in its broad sense. At the same time it would not have meant the extraordinary profits to the company which it may seem to have upon first blush. The conditions existing to-day under which it is impossible to operate the plant profitably as a gift is proof of the fact that such profit as there might have been accruing to the company in the possession of the plant would have been delayed until such time as the plant could be made a commercial success, and during the intervening period it would have been a liability of a considerable necessary expenditure per annum instead of an asset.

In proof of this we have the statement made to you by Col. George J. Roberts, special assistant to the Chief of Ordnance, and the person recommended as president of the proposed operation, that months of time were expended attempting to get the fertilizer industry interested in taking over and operating the Government plants; that the presidents of all the fertilizer companies of the United States were seen and the matter fully discussed with them, and they were asked if they would undertake the operation of these plants if they were to pay no rental to the Government until they had received 9 per cent on their working capital and after that the profit should be divided between them and the Government; that a part of the agreement was that the United States would complete the plants so as to provide storage and bagging facilities and a sulphate of ammonia plant; and yet they could not be brought to the point of making a formal offer.

An effort was also made to get certain financiers in New York to undertake to form a company to operate these plants. Scant consideration was given to the scheme and no investigation undertaken. An appeal likewise was made to the coke-oven interests, with the same result. Is it reasonable to assume that notwithstanding Col. Roberts appealed to the leader of substantially every industry that has knowledge of this business, of which it is proposed that the Muscle Shoals plant shall become a part, that every single one would have declined if there had been any reasonable prospect of profit in the operation of the plant?

The CHAIRMAN. I do not want to interrupt your statement there, but in order that I may understand it and the other members of the committee may understand your statement, let me ask: I understand your statement to be that you were not the only company that was given an opportunity to do this work; that the same opportunity was offered to other people who knew something about this particular industry; and that those other people either turned it down or did not accept the proposition or did not even make an effort to do the work which the American Cyanamid Co. ultimately did? Am I right in that conclusion?

Mr. WASHBURN. I fear I have not made myself clear in my purpose of calling your attention to the fact that this plant was offered, substantially without expense, or I might say absolutely without expense, to various interests if they would operate it. That was done, as was related to you by Col. Roberts. And no one was willing out of these various interests to undertake the work. And I have cited that fact as an indication that even had the American Cyanamid Co. owned a portion of the plant as a result of the contract with the Government to that end, it would have had no extraordinary profit, because the plant at this time and for an indefinite period, and we do no know how long in the future, would be a burden instead of an asset, because even as a gift it is not commercially feasible to operate the plant.

Senator RANSDELL. Do you think, then, that those tentative propositions which seem to have been made—and I believe there were three or four of them—do you think probably they were not as advisable for your company as the one finally entered into with you?

Mr. WASHBURN. I think the plan for our owning a part of the plant was not a feasible one. As I say, it was not politically sound. It would be different for the Government officials——

Senator RANSDELL (interposing). It was a mistake, then, in presenting that proposition?

Mr. WASHBURN. Oh, no; I do not think so. You see the way these things went in those negotiations, principally the men who came to Washington to conduct the Government affairs during the war and the representatives, chiefly the president of the American Cyanamid Co. in this connection, met those men in continual verbal discussions. Then they or I would be asked to write a letter covering the matter. There was always this effort to get something that would provide protection for the American Cyanamid Co. These letters that we see are the things which came to the surface in the effort to commute the demand we made for further protection into something that while it was not protection yet would be as near to it as we could approach.

Senator RANSDELL. If I grasp your evidence as a whole, you are better protected by the contract finally made—that is, the American Cyanamid Co. got better protection out of the contract finally made than it would have gotten out of the tentative propositions which you say might have resulted in giving you a profit that would have been a liability instead of an asset.

Mr. WASHBURN. No.

Senator RANSDELL. That is just what you said.

Mr. WASHBURN. Well, the only protection that any of us could devise in this situation, speaking from the standpoint of protection, was ownership of that portion of the plant which could have a commercial use. I think that is clear as a proposition; that proposition on our part to accomplish protection in that way has, by inference in any event, been presented as showing a grasping disposition on the part of this company to do some war work and then grab everything it did for the Government. I am merely trying to indicate that that proposal was the only logical one for the full protection of the American Cyanamid Co. But even that would not have provided what certain people have attributed to it, because at this time, now pretty nearly two years after the war ceased, and likely for an indefinite time in the future, we would not have been able to do anything with the plant. We should have had to guard it and care for it, etc., and yet had no use for it. Eventually even no one can tell what we could have made out of it. But unquestionably, notwithstanding the burden it would have been to us, we would rather have had full protection in that way than what now promises to be no protection at all.

Senator RANSDELL. I understand you now. You would have been better satisfied to have had your original proposition accepted although you are doubtful whether that would have done very much for you?

Mr. WASHBURN. Yes, sir.

Now, gentlemen of the committee, the expressed conclusion of the Government representative who read to you extracts from various letters addressed to the Government during the period of negotiations seems to convey, if not with strict accuracy, at least substantially, the attitude of the American Cyanamid Co. from the beginning, in which testimony he expressed himself as follows [reading]:

> The first proposal of the American Cyanamid Co. for building the plant was that they wanted protection, and they would get that protection and at the same time be recompensed for all their efforts by owning the plant. Finding that we could not possibly do that for them, they came around to asking for protection in another form.

There is a letter, however, to which the Government representatives have not referred, which shows that not only from the first but also to the very last the purpose of the American Cyanamid Co. was to secure protection against Government commercial competition as far as possible as distinguished from profit or compensation in connection with the work undertaken for the Government. This is a letter of May 9, 1918, written by the Air Nitrates Corporation to Col. Samuel McRoberts, of the procurement division, selected to negotiate the contracts for the construction and operation of nitrate plants 3 and 4, subsequent to the execution of the contracts for plant No. 2 at Muscle Shoals. I quote from this proposition as follows [reading]:

> That neither the undersigned nor the American Cyanamid Co. shall receive any fee for construction, equipment, operation, or otherwise with respect to the plant or plants such as is provided in said agreements with respect to the Muscle Shoals plant, but in lieu thereof the Government shall undertake and agree, in such manner and form as in the opinion of counsel for the undersigned

> shall be valid and binding, that there shall be paid to the American Cyanamid Co. a royalty of 10 per cent of the price at which sold upon and with respect to all products made at such plant or plants, as well as at the Muscle Shoals plant, by the Government or by its lessee, licensee, or assigns for and during the 10-year period beginning January 1, 1922, and thence next ensuing, as well as for and during any period prior to January 1, 1922, in which any such invention, discovery, or secret method or process of the American Cyanamid Co., or as a part thereof or step therein, shall be used by the Government for any commercial purpose.

You will observe that the purpose of this proposition is to place these matters at the service of the Government for military purposes. And this is a part of the letter [reading]:

> You will observe that the purpose of this proposition is to place at the service of the Government for its military purposes in the manner specified the entire mental and technical skill and resources of the American Cyanamid Co., and the undersigned, embracing all their inventions, devices, and secret methods or processes, without compensation, asknig in return only that what is divulged and accomplished thereby shall not be utilized after the date mentioned or for other than military purposes without compensating the American Cyanamid Co. to the extent of what we consider the fair royalty designated.

The **CHAIRMAN**. So that the only compensation the American Cyanamid Co. could possibly receive would be 10 per cent on sales of products?

Mr. **WASHBURN**. Yes, sir.

Now, gentlemen of the committee, the events would seem to prove that our forecasts were based upon reason. We seem to have failed utterly to have acquired any degree of protection in this matter, directly or indirectly. We have no net profits as a result of our work for the Government, and the bill which the administration asks you to favor will, if it becomes law and is carried out in accordance with the proposed plans of the administration as described to your committee in its hearings, result in a portion of the output of the plant going to fertilizer mixers, who, to quote the gentleman who is recommended for the presidency of the Government corporation, "now buy from the American Cyanamid Co."

Upon all the product to be manufactured this gentleman has up to date done all the arbitrating and determining as to what the royalty should be, and fixed it at one-third to six-tenths of the amount set out in the contract. And such a competitor, with its chief ambition, so far as sales policy is concerned, to furnish its product at the lowest possible price to the consumer; with a productive capacity four times our own; specifically setting out to sell to our customers; with the pronounced intention of paying only a fraction of the royalty set up in the contract as a standard; estimating its profits upon a basis of costs which does not include the numerous and important elements of interest, amortization, obsolescence, depreciation, local and State taxes, Federal taxes, insurance, legal expense, advertising, and warehousing; and, finally, if there is left anything to us which it wants, possessing the power to take it by condemnation.

I should like to ask, under the fiction of your having contemplated the purchase of stock in the American Cyanamid Co., whether, if you had made the purchase, you would have felt, facing the situation which this company faces to-day, you had made a wise investment? Would it not be rather far-fetched, in view of the conditions which exist to-day, to view the American Cyanamid Co. in any light except as a benefactor to the United States Government, with no probable net reward and with the very strong possibility of being devoured by the monster which it was forced to create for the protection of the country in time of war?

The **Chairman**. Who was the president of the Air Nitrates Corporation?

Mr. **Washburn**. I was the president of it. It was merely an instrument for carrying out this work.

The **Chairman**. I just wanted the record to be clear.

Mr. **Washburn**. Yes, sir.

Senator **Kendrick**. How many plants has your company in operation in this country?

Mr. **Washburn**. It has three plants in operation.

Senator **Kendrick**. In the United States?

Mr. **Washburn**. Yes, sir.

Senator **Kendrick**. Where are they located?

Mr. **Washburn**. One is located in New Jersey, in what is known as the New York Harbor.

Senator **Kendrick**. What is the capacity of that plant?

Mr. **Washburn**. That plant has a capacity of 30,000 to 40,000 tons per annum of ammonium phosphate. It also manufactures sulphuric acid and ammonia.

Senator **Kendrick**. And where are the other plants?

Mr. **Washburn**. The second plant is in Florida, and is a mining plant for the production of phosphate rock.

Senator **Kendrick**. Does it produce any chemicals that are provided for in this Muscle Shoals plant?

Mr. **Washburn**. No. It produces phosphate rock, from which we make a phosphoric-acid compound of phosphoric acid and ammonia, known as one of the ammonium phosphates.

Senator **Kendrick**. It is really not in competition, then, with Muscle Shoals?

Mr. **Washburn**. No; not in the least.

Senator **Kendrick**. Where is the third plant?

Mr. **Washburn**. The third plant is in California.

Senator **Kendrick**. What does it produce?

Mr. **Washburn**. It produces a chemical for the fumigation of citrus trees.

Senator **Kendrick**. It does not produce anything that would be in competition with the Muscle Shoals plant?

Mr. **Washburn**. No.

Senator **Kendrick**. What is the approximate or estimated production of the Muscle Shoals plant?

Mr. **Washburn**. Sixty thousand tons of cyanamid.

Senator **Kendrick**. What other products, in the way of fertilizer, do they propose to produce there?

Mr. **Washburn**. Where?

Senator **Kendrick**. At Muscle Shoals. Do they not expect to produce another chemical in addition to the one you have named?

Mr. **Washburn**. They propose to fix the ammonium made from the cyanamid or lime nitrogen in the form of sulphate of ammonia.

Senator **Kendrick**. To what extent or in what quantities?

Mr. **Washburn**. I can not answer that, because the Government presents certain possibilities with that plant but forecasts that their principal or practically sole product will be sulphate of ammonia, and in its estimates of costs of sulphate of ammonia it assumes substantially full operation of the plant. Now, that plant is capable of producing over 200,000 tons of sulphate of ammonia per annum.

Senator **Kendrick**. Yes; that was the impression I had. Would that represent and include the 60,000 tons that you have mentioned, or would that mean a total of 260,000 tons?

Mr. **Washburn**. There would be 260,000 tons, I think—the 60,000 tons which this company produces in its plant in Canada, at Niagara Falls, and 200,000 tons or over of sulphate of ammonia at Muscle Shoals by the Government.

Senator **Kendrick**. Do you know of any other nitrate plant in the country that is producing the same fertilizers or the same chemicals or nitrates that your company is producing and that would be in competition with the Government?

Mr. **Washburn**. No.

Senator **Kendrick**. Then your company represents about the only company in competition with this plant at Muscle Shoals; is that so?

Mr. **Washburn**. No; your question was whether there were any companies producing these materials that the American Cyanamid Co. is producing, and my answer is that there are none.

Senator **Kendrick**. My question was intended to develop the fact as to whether or not there were any other plants in competition with the Muscle Shoals plant or that of producing commercially articles that are to be produced at Muscle Shoals.

Mr. **Washburn**. The whole by-product coke-oven industry would be in direct competition with the Muscle Shoals plant.

Senator **Kendrick**. But you are not interested in them?

Mr. **Washburn**. No; we have no interest in them.

Senator **Kendrick**. Then your opposition is based upon the principle that the Government ought not to develop a plant here of this magnitude, producing, we will say, 200,000 tons, according to your estimate, because of the injurious effect upon your plant that is producing 30,000 tons?

Mr. **Washburn**. I think you meant to say 60,000 tons, not 30,000 tons.

Senator **Kendrick**. Oh, did you say 60,000 tons?

Mr. **Washburn**. Yes.

Senator **Kendrick**. I thought you said 30,000 tons.

Mr. **Washburn**. No; 60,000 tons. We do not produce now any sulphate of ammonia, but we produce cyanamid, which, so far as its nitrogen content is concerned, is equivalent to about 60,000 tons of sulphate of ammonia. The nearest comparison we could make on a competitive basis, if we should speak of them in that way, of the Muscle Shoals plant and the operations of the American Cyanamid Co., would be that the American Cyanamid Co. is producing the equivalent of 60,000 tons of sulphate of ammonia and that the Government would be producing 200,000 tons.

Senator **Ransdell**. I am not perfectly clear on that matter. You say the Muscle Shoals plant would produce 60,000 tons of this lime nitrogen—is that what you described it as being?

Mr. **Washburn**. Yes, sir.

Senator **Ransdell**. And that 60,000 tons of lime nitrogen could be converted and probably would be converted, under the plan of the

Government, into about 200,000 tons of sulphate of ammonia. Is that the idea?

Mr. WASHBURN. No.

Senator RANSDELL. How many tons of sulphate of ammonia would 60,000 tons of lime nitrogen make?

Mr. WASHBURN. Sixty thousand tons of sulphate of ammonia.

Senator RANSDELL. I did not quite grasp then, if the plant would only make 60,000 tons of lime nitrogen, how it could make 200,000 tons of ammonium sulphate.

Mr. WASHBURN. But the capacity of 60,000 tons of lime nitrogen is the capacity of the American Cyanamid Co.'s plant at Niagara Falls, Canada; and the capacity of the Muscle Shoals plant is such as to enable it to produce over 200,000 tons of sulphate of ammonia.

Senator RANSDELL. All right. I am clear on that now. I misunderstood you.

Mr. WASHBURN. All right.

Now, gentlemen of the committee, may I be permitted to recall to your minds my general contention in connection with the Muscle Shoals situation, because the substance of the testimony of some of the witnesses who have appeared before you since I was here last, and the plain inference to be drawn from their testimony, would indicate that my position in this situation was either forgotten or misunderstood.

I have made it as plain as I know how to make it that I believe the Muscle Shoals plant should be conserved to the country as a great industrial plant. I differ from the Government or administration's point of view in that to start the plant now would be an economic loss instead of an economic gain to the country, and that whenever it shall be placed in operation it should be under the management of a private industrial organization and not as a Government opera-

I come now to those factors which are determining ones, I believe in the judgment of every one who has viewed this matter; not all the determining factors but some of the principal ones: (1) Preservation of the plant; (2) fresh capital; (3) demand for the product; (4) cost of production, which has relation, of course, to profit or loss.

As to the first of these factors, preservation of the plant, the administration has advanced as an argument for the placing of Muscle Shoals plant in operation at this time the claim that if the plant shall stand idle it will deteriorate at a rate which will render it useless when it shall become necessary for any reason to place it in operation. Generally speaking, I agree with this proposition as a question of indefinite idleness, such as the period that normally intervenes in this country between the end of one great war and the undertaking of the next; but I emphatically deny that it is impracticable to keep the Muscle Shoals plant in idleness and in a condition substantially as good as new for a period of years until, as I stated to you at the time of my former appearance here [reading]:

> The conditions which face the world have ameliorated and been adjusted so that there is some economic purpose and profit, and value and significance in the operation of that plant and in the use of the product, and when that time shall come it seems to me it is proper for private interests to handle it rather than the Government.

See page 543, volume 4 of the hearings.

I think in this matter we are again in danger of going astray if we generalize, and therefore I will for the moment invite your attention to a few details of this matter of preserving the plant; particularly in view of the fact that the extreme contention of the administration that even four or five years of idleness will, according to the Secretary of War, find the plant "not worth operating," is inconsistent with the very plan which the administration puts forth for the operation of the plant. This inconsistency as I see it lies in the fact that under the administration plan a large part of the plant will either remain indefinitely in idleness or continuously idle for considerable periods. This is particularly the case with the very kind of equipment for whose preservation the administration representatives have expressed the deepest concern, namely, the electrical equipment. It is as you know the purpose to substitute water-power for the great steam power plant, thereby throwing the steam-electric plant out of commission. Furthermore, under the administration plan as announced to you practically the whole of the acid plant, constituting roughly half of the entire plant, will be idle all the time.

Idleness of necessity under any plan will be the condition, as you will clearly see, unless the whole plant is to be used at its full capacity for the production of the material for which it was built, namely, nitrate of ammonia. In other words, according to the administration plan, set forth on page 92 of the printed testimony before this committee, the only material which it is proposed to produce in the acid plant is 23,000 tons of nitrate of ammonia. This is one-fifth of its capacity, and therefore four-fifths of the plant must stand in idleness. The logical conclusion from this, according to the administration line of argument, would be that four-fifths of the plant would deteriorate and become useless. Furthermore, for reasons set out later it will be impracticable to operate the plant to anything like full capacity, leaving one-half to two-thirds of it idle for very long periods at least.

There was read before you an extract from the testimony which I gave before the Committee on Military Affairs, House of Representatives, February 11, 1916 (p. 157) in which I stated, among other things, that——

> A country which should rely for its powder supply upon the practically indefinite maintenance in working order of an idle plant * * * would be taking a most extraordinary risk.

It is no part of my purpose, and I have been particular to repeatedly state it, to put forth any plan which contemplates the indefinite idleness of this plant. That the plant can be preserved in idleness in a condition practically as good as new for a period of 5 or 10 years, or even longer, is entirely consistent with my earlier expressions of opinion in this matter.

The administration representatives have also given as a reason for placing the plant in immediate operation that unless it were done the plant could not be started from an idle condition in a reasonable time because of the lack of a sufficiently trained body of men. I was also very strongly of this opinion until we had the actual experience with the operation of the Muscle Shoals plant; in the past I felt that it might even take as much as a year to get the plant into full stride. Barring the deterring effect of the declaration of the armistice we would not only have had the plant operating to substantially full capacity, but would have constructed it from the foundations up within the period of a year. Our actual experience has demonstrated that it would be possible, with the excitement attending the initial stages of the war, by using as a nucleus the trained body of men elsewhere engaged in this industry, to place the Muscle Shoals plant in full operation in four months. This is due in large measure to the fact that the equipment of the plant is composed of large unit labor-saving devices to the last degree.

Like most matters, it is a question of expediency. If it were economically and industrially sound to operate this plant at the present time to its full capacity it would unquestionably be the most effective way of having it in instant and perfect readiness for operation in the event of war. It is also possible—but at a cost of maintenance which would be prohibitive if the plant could be profitably employed—to preserve the plant idle in perfect condition.

The next matter is that of fresh capital.

The CHAIRMAN. Before you leave that subject let me ask: I think it was stated by some of the Government representatives that it would cost $400,000 a year to preserve the plant if it was kept in idleness. Have you any suggestions to make along that line or do you care to make any comment on it?

Mr. WASHBURN. No; I do not know that that estimate is out of the way.

The CHAIRMAN. All right.

Mr. WASHBURN. I have made no estimate to check it.

The CHAIRMAN. Was not that statement made, Maj. Gaillard, that it would cost $400,000 to $500,000 each year to take care of that plant if standing idle?

Maj. GAILLARD. Yes, sir.

The CHAIRMAN. You may proceed with your statement, Mr. Washburn.

Mr. WASHBURN. The Secretary of War in his second appearance before your committee, April 20, took issue with the statement which I made to you that under the Government plan $38,000,000 of fresh capital would be required to place the Muscle Shoals plant in operation; $25,000,000 of the $38,000,000 was the last Government engineers' estimate of the cost of the dam and power equipment. In support of his argument the Secretary states—

> that the expenditure of $25,000,000 to carry out the Muscle Shoals project is not new capital for this one enterprise in any sense. As a matter of fact the primary 100,000 horsepower which are to be developed at the Muscle Shoals dam will be used by this nitrogen plant for the manufacture of fertilizer. The next 100,000, which will be equally available by the supplementing of the dam at low stage with the already constructed and operating steam plant, will be available for distribution for industrial uses throughout that whole section of the country.

Further on Senator Smith of South Carolina asked the Secretary of $25,000,000 was the estimated cost of the dam, and his answer was:

> Oh, it will take a great deal more than that Senator. We have expended there $7,000,000. We have there now the preliminary dams. (Meaning by that the cofferdams for exposing the foundations.) We have roads. We have the concrete bridges. We have the houses for the laborers. We have everything there now except sunshine and low water to build the dam. And a part of it is built. If we were to stop and scrap the Muscle Shoals dam it would mean wasting the $7,000,000 we have already expended.

I submit that this unfolds a most remarkable situation and one which I believe will astonish not only the members of the legislative branch of the Government, but every one who has given more than passing consideration to this situation. It is a flat declaration that the United States Government proposes to go into the business of electric power generation, transmission, and sale. It is a flat declaration that the $13,159,610.42 taken from the $20,000,000 appropriated under the nitrate section of the national defense act of June 3, 1916, is for the purpose of establishing the Government in the power business through this new corporation which you are asked to create, and not for any purpose involved in national defense.

The first question which seems to me pertinent to raise is whether there is any authority under the nitrate section of the national defense act for the use of moneys for the purpose of putting the Government into the power business? It was clearly the intent of the act and it is clearly set out that any power development which the Government may undertake under this appropriation shall be, to quote the act—

> for the generation of electrical or other power and for the production of nitrate or other products needed for munitions of war and useful in the manufacture of fertilizer and other useful products.

Furthermore, approximately $13,000,000 to be taken from this appropriation is substantially only half of the last engineers' estimate, and still a smaller part of what the real cost of the power development will be. If it is the contention of the administration that they have a right to take moneys from the nitrate supply section of the national defense act for the purpose of starting commercial power projects on their way they could just as logically have started 13 power enterprises in 13 sections of the United States, and then when they were partially completed have come back to the Congress with the demand for unlimited additional millions in order to save money already invested.

But we are faced with the further astounding fact that, according to the Secretary of War, a great deal more than $25,000,000 will be required and the statement that $7,000,000 has already been expended and that that amount will be wasted if the work at Muscle Shoals is to stop. It would seem from this that no part of the $7,000,000 is in the matter of commitments, but, as the Secretary states, is the amount "we have already expended."

The CHAIRMAN. Mr. Washburn, do you intend to go into the probable cost of completing this dam and of completing this project based upon the price of labor at the present time and the price of materials necessary in the construction of the dam? Have you anything of that kind mapped out?

Mr. WASHBURN. Yes; I have, Mr. Chairman, and our study of the situation indicates that to complete the dam and to install 100,000 horsepower, such as Col. Roberts expressed as the purpose, will take, as the Secretary says, an amount very much in excess of $25,000,000, and, as we figure it, $39,000,000; and that to complete the installation of the additional equipment which the Secretary says may be placed there, will take an additional $11,000,000. In other words, the Muscle Shoals dam and power plant will involve the expenditure of $50,000,000. In addition to that, to meet the Secretary's proposition that the navigation interests would have warranted the building of the dam, before navigation could be effective over Muscle Shoals—because this expenditure I have mentioned is only on a portion of the shoals—there will be required on the shoals themselves an additional $25,000,000, including the possible power equipment for dam No. 3.

Senator **Ransdell.** Do you mean that another dam will be necessary?

Mr. **Washburn.** Yes, sir; another dam and a great deal of additional navigation work, in the way of retaining walls, locks, and so on.

The **Chairman.** That would make a total of $75,000,000 as far as you have gone?

Mr. **Washburn.** Yes, sir. And then Col. Roberts in his testimony before you stated that it would take for distribution of power $29,000,000, which would make a total of $104,000,000. And then before navigation would have any significance at all, because this whole expenditure would merely result in navigation over the shoals, it would be necessary to expend on dams above Decatur, the headwaters of this last No. 3 dam, somewhere in the neighborhood possibly of as much as $5,000,000. So that there will be over $100,000,000 involved in carrying out the project as it now assumes shape before navigation could be provided for.

To repeat, there is involved the expenditure of $39,000,000 in this present dam which the Government is at work upon to provide the 100,000 horsepower intended for use in the Muscle Shoals plant. And, in addition——

Senator **Kendrick** (interposing). Did you make an estimate of the cost of this dam during the discussion of this matter with the War Department at the time the war was on? Did you make any estimate of cost to complete this dam and the power plant and the operation of the Muscle Shoals plant?

Mr. **Washburn.** No; I have not.

Senator **Kendrick.** Have you ever made at any place at any time any estimate of it before this time?

Mr. **Washburn.** Yes; I made estimates extending back as far as 1906 or 1907.

Senator **Kendrick.** Did those estimates correspond with these figures you have given us this morning?

Mr. **Washburn.** They correspond in the sense that they are consistent with the present estimates taking into account the changes in plans and the change in the labor market, in labor efficiency and in the materials' market and in the interest rate.

The **Chairman.** Of course the figures at that time were much lower than now.

Mr. **Washburn.** Oh, yes, sir.

The **Chairman.** The amounts named at that time were lower than those you name now?

Mr. **Washburn.** Yes, sir.

Senator **Kendrick.** Is it your contention that it will take—what was that aggregate, $109,000,000?

Mr. **Washburn.** Yes, sir.

Senator **Kendrick.** Is it your contention that it will take an investment there of $109,000,000 to furnish power to operate this plant that the Government has at this time?

Mr. WASHBURN. No. That is not the statement as I intended to make it. My belief is that it will take $39,000,000 instead of $25,000,000, and——

Senator KENDRICK (interposing). I wanted to make that clear because you reached the figures $109,000,000, and we are dealing now as I understand it with power for these plants that we have at this time and that are already constructed.

Mr. WASHBURN. Yes, sir.

Senator KENDRICK. So there is a variation or difference between the estimates of $25,000,000 on the part of the Secretary of War and your estimate of $39,000,000?

Mr. WASHBURN. Yes, sir.

Senator KENDRICK. That means a difference of $14,000,000?

Mr. WASHBURN. Yes, sir.

The CHAIRMAN. That is for the dam?

Mr. WASHBURN. Yes, sir; for the dam and 100,000 horsepower of hydroelectric power, the express significance of which, according to my contention, is that that expenditure is being made in spite of the fact that there is ready, waiting and idle, a steam plant ample to operate the whole Muscle Shoals plant, and which may be operated at no greater expense to the Government than the operation of this water-power plant after it is completed.

Senator KENDRICK. Yes; that is true, but it is not also true that water power, if properly constructed and properly managed, is enough cheaper than steam power to amortize itself within a reasonable length of time?

Mr. WASHBURN. That may be so under certain conditions, but the conditions do not exist at this time for accomplishing any such purpose at Muscle Shoals.

Senator KENDRICK. You mean, of course, at present prices over and above the normal cost, that that would prevent it from being done?

Mr. WASHBURN. Yes; and——

Senator KENDRICK (interposing). Because the price at the present time is so far above the cost in normal times.

Mr. WASHBURN. That is a very important factor and possibly the most important single factor, but we have also the consideration here that that steam plant is there and that interest is going to run against it, whether it is operated or is no operated. The hydroelectric plant is not there, and the money that goes into it must have interest paid upon it, which is a fresh expenditure.

Senator KENDRICK. Is it true that the life and usefulness of the construction proposed by the Government would be practically unlimited, would in fact be perpetual? That is to say, the outlay would be of the kind that would never have to be rebuilt in hundreds of years; isn't that true?

Mr. WASHBURN. That is true, with the modification which I know you must have had in mind also, that there must be renewals and replacements of apparatus from time to time.

Senator KENDRICK. Oh, yes.

Mr. WASHBURN. Yes, sir.

Senator KENDRICK. But it would practically perpetuate the use of that power without anything except incidental maintenance.

Mr. WASHBURN. Yes. But there would be perpetuated incidentally with that a high interest rate against two and a half times what the cost might ordinarily be.

Senator KENDRICK. Isn't it a fact that we have seen in the past cheaper fuel than we are ever going to see again in this country?

Mr. WASHBURN. In making the comparison between the cost of steam power to the Government and the cost of water power I have taken fuel at the extraordinary present price of $4.65 a ton, less than which I am extremely confident coal will eventually be sold, when we get these world matters adjusted. We are not likely to continue coal at $4.65 a ton.

Senator KENDRICK. It is estimated by those who have made a study of the situation that there is a limit to the supply of coal in this country. Under such conditions, it would seem that two things must happen: First, that the cost of it would be increased somewhat because of difficulties of operating, and, secondly, the sternest kind of necessity for the conservation of it for purposes where it would be almost if not out of the question to employ water power.

Mr. WASHBURN. Eventually water power at Muscle Shoals will have a valuable economic use in the saving of coal, but we must not, it seems to me, assume the burden because water power by developing it at this time will have the economic significance when it is placed in operation of wasting millions of tons of coal. Because, after all, the question of coal as against water power is also commutable into the cost of the one thing as compared with the other. We would not be warranted, for instance, in order to save 1 ton of coal, in spending millions of dollars. You have got to institute some kind of quantitative analysis of the situation, and that quantitative analysis at the present time shows we are doing the equivalent of trying to save 1 ton of coal by spending a million dollars, as an illustration.

Senator KENDRICK. That is an impossible illustration. But the time must come pretty soon when we will adopt the policy of conserving this coal, to be employed, as I said before, where other means of power can not be employed. There will be a time undoubtedly in the course of events when our resources will be limited like they are in foreign lands. We have heard of coal being sold in Italy during the last war, if I remember correctly, at $60 a ton, and unobtainable at that price. This Nation might well forecast these things and take such steps as it can to prevent that kind of condition.

Mr. WASHBURN. I quite agree with you, Senator. The thing I have contended for here for a great many years is right along that line. But it seems to me that it should be done at the appropriate time, when it can be done without the expenditure of more energy than you are saving. In this situation from the viewpoint of every single individual engaged in the great industry of power development and things similar to it is the very time of all others when not a dollar that is not absolutely necessary should go into water power.

Senator KENDRICK. I think it is well to develop these facts. I do not want to prolong the discussion unnecessarily, but my attitude of mind is that we in this particular case that you have mentioned, of avoiding the investiment of this money, have the choice of one of two things, not exactly as it applies to this power business, but as it refers to the whole question: We have the choice of employing this plant, which as I recall the estimate cost $62,000,000, in something like a self-sustaining way. We will not call it a remunerative way, but a plan by which it will sustain itself or even return a little interest on the money. Or, we will allow the plant to stand idle and avoid investing a few millions of dollars more.

The statement I have made probably is awkwardly made, and I should have stated that we have the opportunity to expend this additional money in order to make the plant productive and self-sustaining, expend the amount you refer to. It would seem that no man of economic judgment would allow a plant costing $62,000,000 to become ineffective because of a disinclination to expend, say, a third of that amount in completing the plant, an additional $20,000,000 or $25,000,000 to complete the plant. In other words, we waste or lose the use of $62,000,000 one way; the other way we go on and complete the plant and put it into operation. No man of business judgment would sanction that kind of thing, whether it be the Government or private industry, it seems to me. There is no reason under the sun that would induce the business man to do that.

Mr. WASHBURN. If that were the aspect in which the thing appeared to a business man he would have to reach the same conclusion you have reached. But if I can properly sense the business point of view of that situation it does not resemble that state of affairs.

Senator KENDRICK. The economic law applies. You must either lose the use of that plant or you must complete it and put it to work. Over against that is your argument as I understand it, and I want to be sure that the committee gets your actual viewpoint; over against that is the argument that the Government has no right to become a competitor in the production of these materials and to compete with industry that is now furnishing to the country—what we will say is 60,000 tons of ammonia annually, as being your capacity. What percentage of the total amount used is that, Mr. Washburn? Do you know what the total of the amount of that product used in the Nation is? Isn't it 550,000 tons?

Mr. WASHBURN. It is. The productive capacity of the country expressed in sulphate of ammonia equivalent is 550,000 tons of sulphate of ammonia.

Senator KENDRICK. That was my understanding.

Mr. WASHBURN. Senator, may I give the aspect of that situation paralleling your own viewpoint except as to the quantities involved?

Senator KENDRICK. Certainly.

Mr. WASHBURN. Instead of having, as we see it, $62,000,000 invested in a plant there which can be placed to work, if the administration plan is carried out of providing water power for the plant—and according to the administration plan that is necessary, because they have told you that there is nothing attractive either to the Government or to private capital in operating the Muscle Shoals plant unless it is operated with water power. Now, while there was $62,000,000 expended down there—and something more than that, in fact—the part of the plant which it is proposed under these plans, and which would seem to be all that can be placed in use, represents of that $62,000,000 somewhere from $30,000,000 to $33,000,000. And of that $30,000,000 to $33,000,000 of plant in ordinary times—such times as we have had before this war, and even more severe times—private interests would duplicate all that the Government is going to do there, or has in value, for $15,000,000. Now, my contention is that the administration plan contemplates the expenditure of $38,000,000 in order to use what is normally of plant and equipment value of $15,000,000.

Senator **Kendrick**. Let me ask this question right there: Do I understand that your company, acting for the Government, has expended in the construction of this plant $62,000,000, whereas within one or two short years afterwards private capital would put it up for $15,000,000?

Mr. **Washburn**. No; that would not be the right aspect of it. Here is an expenditure of $62,000,000. Over here is a part of the plant which the Government proposes to use, and this other part of the plant will stand idle. That part of the plant, the total cost of which was $62,000,000, is from $30,000,000 to $32,000,000 in value. Things are costing now two and a half to three times—or did during the war—what they would most in normal times.

Senator **Kendrick**. Are they not costing just as much now?

Mr. **Washburn**. They are costing more now.

Senator **Kendrick**. I thought that.

Mr. **Washburn**. Therefore, if we can think in normal figures, I should say that what cost $30,000,000 to $33,000,000 could be normally replaced by an expenditure of $15,000,000.

Senator **Ransdell**. Normally, but not to-day?

Mr. **Washburn**. Yes; normally, but not to-day.

Senator **Kendrick**. You said that it could be done now.

Mr. **Washburn**. Well, that was a complete error, if I said it could be done now. Normally is the word I meant to use.

The **Chairman**. You may proceed with your statement, Mr. Washburn.

Mr. **Washburn**. Now, as to the statement that $7,000,000 has been expended on the dam already and that that would be wasted, our figures indicate—and we have made up an estimate in our own organization here of what has been expended, which shows only $800,000, which is a pretty good check on the Secretary's statement—but we show that the loss for the work if it should stop at this moment would not be the $7,000,000 referred to but $2,750,000—that is, if the work was stopped now and the whole thing abandoned until such time as the work could be undertaken with a better market. To conclude now as to whether we were logical in estimating that $25,000,000 of fresh money would be involved in the building of that dam, the Secretary of War takes out $7,000,000 and leaves $18,000,000. But our belief is that instead of $25,000,000 it is going to be, as the Secretary says, a great deal more expensive, and is going to run about $39,000,000. And even if the whole $7,000,000 were a loss, we would have still left $32,000,000 of fresh money going in there instead of $25,000,000, as we have formerly stated, basing it upon the engineers' estimate—which I might say we have felt for a long time, in fact ever since it was made, has not had the full confidence of the engineers themselves or anyone else as to what that work will cost at the present time.

It is not inappropriate to again call attention to the fact, which every power expert in the country knows as the very fundamental principle in his calling, that even if the hydroelectric-power project has an economic basis it should be built when it can be built the cheapest and not, as in this case, at a time when it will cost more, and very much more, than in any other period of the country's history.

Now, I come to a situation which is puzzling and I will deal with it in the best way I know how.

Senator RANSDELL. I would like to ask a question or two right there: The bill we are considering provides for the issuing of stock in the amount of $12,500,000; in other words, an appropriation of $12,500,000. As I gather from a reading of the bill, it is for the operation and development of the plant which we aready have at Muscle Shoals rather than for any considerable expenditure in further construction. Am I wrong in that; if so, why do we provide for only $12,500,000? If we are to start out and expend what you say, $38,000,000 or $39,000,000 to build the dams, it would take two or three years at least, wouldn't it?

Mr. WASHBURN. Yes, sir.

Senator RANSDELL. What in the meantime are we to do with $12,-500,000? And are we contemplating here the expenditure of this money for the completion of the dams? I am confused on the matter.

Mr. WASHBURN. There is no appropriation contemplated in this bill for work upon the dam; $13,000,000 has been appropriated and is now being expended upon the dam.

Senator RANSDELL. That is in the hands of the Secretary of War or some other official of the Government?

Mr. WASHBURN. Yes, sir. Now, where the additional millions are to come from, of course, I have no knowledge.

Senator RANSDELL. But it is not contemplated in this bill we are now considering?

Mr. WASHBURN. No, sir.

Senator RANSDELL. What do we contemplate in this bill, as you understand it? What does this $12,500,000 mean? What is to be done with it? I think all of the members of the committee would like to know. I do not want to break into your line of thought, but it would help me to know right now what we are to do with this particular money mentioned in this bill.

Mr. WASHBURN. The important thing here is for the committee to be fully informed, and that is the only effort we are making here, is to inform the committee.

Senator RANSDELL. Yes, sir; and that is what we want—information.

Senator KENDRICK. I think that was rather clearly set forth, Senator Ransdell, by the Secretary of War and the members of his official staff when they were here.

Senator RANSDELL. Probably it was; but I do not recall it, and I would like to have it mentioned somewhat briefly now.

Senator KENDRICK. Hasn't that been explained, Mr. Chairman?

The CHAIRMAN. Yes; that has been gone into from the War Department's viewpoint.

Senator RANSDELL. But Mr. Washburn is going into a lot of other things which seem to me to be beyond the bill we now have under consideration, and I want to know what it means.

Senator McNARY. He is discussing the whole plan of the Secretary of War rather than just what is contained in this bill, as I understand it.

Senator RANSDELL. All right.

Mr. WASHBURN. On page 93 of your hearings there is a statement, the details of which seem to sum up the $12,500,000 appropriation.

Senator RANSDELL. Is that the statement there at page 93?

Mr. WASHBURN. Yes, sir; in a letter, I believe, from Mr. Arthur Glasgow, who was appointed nitrate director after the armistice. See page 93.

Senator RANSDELL. I see it is signed by Arthur Glasgow. That sets forth, I suppose, very fully the situation from the administration standpoint, and I will read it. Please tell me, in view of that, why you are going so fully into things that do not seem to be included in this bill? I suppose they are tied up with it, but they are apparently beyond this bill.

Mr. WASHBURN. I am going into that, Senator, for the reason that it has been represented here that the Muscle Shoals plant can be properly operated by the Government at this time by the substitution of water power for steam power, combined with the statement that the project which the Government puts forward has no attractions either for the Government or for private capital unless it does use water power. In showing that it is attractive with the use of water power they eliminate all interest upon the moneys necessary to complete that water power, just as they have eliminated in other costs all interest on moneys already expended. And I have called to the attention of your committee for the first time that your committee has had it called to its attention that there is involved in this situation not merely salvage on a plant which cost $62,000,000, but salvage on what is ordinarily available at $15,000,000, with a fresh expenditure of $38,000,000, composed of $25,000,000 in the hydroelectric power plant and $12,500,000 asked for from your committee and $500,000 in certain electrical transmission equipment.

Senator RANSDELL. Suppose our committee does not give the $12,500,000 or some other sum, what is going to happen to the plant that we have there?

Mr. WASHBURN. It would have the same treatment that other plants have had, and that battleships have, and that fortifications have—it would be kept in condition by the Government with this expectation, a belief that everybody has, I imagine, that the time will come when the plant will have an economic value to the country. And when that time shall come the Government has provided in its contract with the people who own the patents and processes by which the plant can be operated by private capital.

Senator RANSDELL. Your theory is that the time will come within the next 5 or 10 years, probably?

Mr. WASHBURN. Yes, sir.

Senator RANSDELL. And Maj. Gaillard said it would cost $400,000 a year to maintain the plant. Am I correct about that, Maj. Gaillard?

Maj. GAILLARD. Yes, sir.

Senator RANSDELL. And the Government must expend from $400,000 to $500,000 a year to maintain it in status quo?

Maj. **Gaillard.** Yes, sir.

Senator **McNary.** You are treating it as a matter of national defense rather than as to whether nitrogen can be manufactured profitably; is that your position?

Mr. **Washburn.** It is a very valuable asset of being a reliance of this Government for an explosive material in event of war that nothing should be done so far as we can use it at this time to destroy the possibility of that plant being placed in the manufacture of explosives at some future time. And it will have, we believe and hope, an economic value at some time, but at the present time it has no economic value for the reasons which I have tried to lay before the committee here in my previous hearings, some of which I am going to review to-day.

Senator **Ransdell.** Economic value refers to value of the product as a fertilizer, doesn't it?

Mr. **Washburn.** Economic value refers to a number of things; to its value as a fertilizer and to its effect, for instance, upon the byproduct coke-oven industry. This material comes in direct competition with that, and——

Senator **Ransdell** (interposing). Very well. I understand that, I think.

The **Chairman.** You may proceed with your statement, Mr. Washburn.

Mr. **Washburn.** But this eleventh-hour contention of the administration that the hydroelectric power plant is not to be used for the nitrate plant alone is the only logical attitude that the administration can possibly take and show any reason whatsoever for constructing the dam and power plant. This is due to the fact, with which you are already familiar, that there is in existence and idle, constituting a part of the nitrate plant itself, a steam electric plant which can be operated at no greater cost per horsepower than it will cost the Government to provide hydroelectric power from the Muscle Shoals dam. There must be some reason to account for a duplication of power plants at a perfectly enormous and extraordinary cost when the existing plant is sufficient for the purpose and will cost no more to operate than the proposed new plant.

These do not comprise all the difficulties in this situation. There has seemingly been a complete change of front on the part of the administration within the past few days relative to the proper place of the proposed hydroelectric power plant. In the presentation of the administration's case before your committee by Mr. George J. Roberts, the gentleman recommended by Mr. Arthur Glasgow to be made president of the new proposed Federal corporation, and contained on page 82 and following pages in the report of the hearing before your committee on Senate bill 3390, Mr. Roberts proceeds to show at great length the impracticability of using the Muscle Shoals Hydroelectric Power Plant for commercial purposes.

To this matter I would like to draw your particular attention.

Senator **McNary.** Who was that man?

Mr. **Washburn.** Col. George J. Roberts.

Senator **McNary.** All right.

Mr. **Washburn.** He says:

> Shall this power be sold to large consumers. * * *

That is, to existing electric power companies.

> * * * or sold to the general public? * * * . Before we begin the distribution of power we will have expended, if to only large consumers (for distribution systems) $15,700,000; if to the general public (for distribution systems) $29,200,000.

He states that the market for this power is only at remote points and that the whole cost to the lessor would be over 1 cent per kilowatt hour, while, in his own language:

> The cost of operating its (the lessor's) own plants, including interest, depreciation and taxes, would not exceed seven-tenths of a cent per kilowatt hour.

Therefore we see that it is the conclusion of the administration representative, supposedly best qualified to deal with this situation and pointed to as the business man in the organization, that it is impracticable to generate power at the Government plant for distribution by the existing power companies, but he goes on to say:

> As I read section 124 of the national defense act, the Government must operate this hydroelectric plant and sell the current to the ultimate consumer. It is prohibited from selling to any of the existing electric power companies.

He then takes up consideration of the possibility of the Government furnishing the public with power and states:

> If this energy were disposed of to the ultimate consumer, it would displace power stations of the various companies who are now serving their communities and would destroy the value of these companies' power plants, whose replacement cost at present prices would be not less than $100 per kilowatt, or $15,000,000. It would displace $7,500,000 of their distribution system and make it useless. This means that it would make power plants idle whose present reproductive value is $15,000,000 and it would make distribution systems idle worth $7,500,000 without serving any useful purpose, since these plants are now serving their communities efficienctly and cheaply. It would have a very serious effect on the development of utilities throughout the South and would seriously injure the credit of the companies who for the past 25 years have been building up large power companies for the development of manufacturing throughout the South. If these power plants (that is, the Government power plants) are not used to manufacture nitrates they will have to be operated as commercial power plants. Shall we destroy industry or promote it?

The Secretary's answer, gentlemen, to his chief assistant in this whole enterprise, as I interpret it, is that the Government will destroy industry and will not promote it under the plan which the Secretary, at his hearing before you on the 20th of April, assured you was the plan of the administration.

Senator KENDRICK. Are you there quoting Col. Roberts or making a statement?

Senator McNARY. That last statement was Mr. Washburn's deduction from the statement made by Mr. Roberts; wasn't it, Mr. Washburn?

Mr. WASHBURN. Yes, sir. The remaining item of the $38,000,000 which I have claimed is fresh capital and which the administration representatives say is not fresh capital because they would be able to dispose of $12,500,000 worth of nitrate of soda now held in stock for military purposes. This they figured to be equivalent to 150,000 long tons of Chilean nitrate.

They stated in the hearing before you on the 21st of April that it would take about one year's full operation of the Muscle Shoals plant to replace this 150,000 tons which will have been disposed of. Certainly under no conceivable circumstances is it reasonable to assume that a capacity to produce 150,000 tons in one year is equivalent as a military safeguard to the having of 150,000 tons at the beginning of the time when the war threatens or breaks out. This I submit is a reasonable statement regardless of the degree of preparation which the country may otherwise make.

Let us examine into what would be involved in an attempt to produce at Muscle Shoals this 150,000 tons of nitrate of soda, or its equivalent in nitric acid. The Government representative has stated to you as follows:

> It is admitted that the distribution of that nitric acid to the explosive and powder companies is not thoroughly worked out. That would be one of the problems which this corporation would have on its shoulders. You can distribute it as nitric acid, but it is quite a mean task, because you have got to mix it with sulphuric acid, which would have to be sent down there. But there is another way that the Germans used; they converted that nitric acid which they formed back into sodium nitrate through a synthetic process, and then they distributed this sodium nitrate to the various powder factories and to the various explosive factories in exactly the same way that they would if they were getting sodium nitrate from Chile. We have the way to made sodium nitrate synthetically from such a plant as we have at No. 2.

Now, the administration is urging that there would be no investment of fresh funds chargeable to the Muscle Shoals plant if they should dispose of 150,000 tons of Chilean nitrate; but where is the money to come from and how much will it take to accomplish what the Government representative tells you is a problem not yet worked out? I can possibly give you some figures on this. It goes without discussion and no one will deny that nitric acid, before any means can be devised for shipping it, must be concentrated. A concentrating plant for the equivalent of 150,000 tons of nitric of soda per annum would cost $3,000,000. But your costs do not end here; as the Government representative has told you, sulphuric acid must be brought in, and there is an additional investment involved, how much I can not pretend to say because much study would have to be given to the best means of making a shipping mixture. There would be an additional great cost to the Government for transportation of sulphuric acid into the plant and out after its mixture with the nitric acid.

If we abandon this troublesome, undeveloped, and expensive method of using plant No. 2 for supplying nitric acid, as the Government representative evidently believes would have to be done, and go to the method enforced upon the Germans during the war of making nitrate of soda, we have confronting us, as the Germans had, the enormous cost of this method, and the difficulty of procuring the requisite soda ash or caustic.

This thing must be followed through to the end. If they are going to make nitric acid at Muscle Shoals they must have either soda ash or caustic soda.

There would be required 200,000 pounds of soda ash costing $4,500,000 at present market prices, or 150,000,000 pounds of caustic soda costing say $9,000,000. This in addition to whatever the plant for making nitrate of soda ash or caustic at all in the event of war without robbing equally important uses. It is as scarce and as necessary in war, and relatively as large quantities are required in the manufacture of powders as nitrate of soda itself.

Clearly either method of making use of the Muscle Shoals plant to replace the released 150,000 tons of Chilean nitrate might easily involve the Government in a far greater cost than the retention of the material.

Let us assume, however, that the Government would in the course of time at some cost find a method of handling this problem of making and shipping nitric acid or nitrate of soda from the Muscle Shoals plant, and that upon the outbreak of war it should start to do this. The manufacture of nitric acid to the limit of capacity at Muscle Shoals requires only half of the ammonia which can be produced at Muscle Shoals. What would be done with the remaining half of the ammonia? So far as I know it would have no use whatsoever and, therefore, the plant would have been deprived of fulfilling its original purpose, and half of it would stand idle while war was going forward.

There is one other method for enabling the Government to dispose of 150,000 tons of nitric of soda suggested by the question put by one of the Senators to the Government representative as follows:

> Is it not reasonable to assume that with the plant in operation that we could soon, if we thought best to do so, reinforce our supplies from the production of the plant?

The answer was—

> Yes, sir; it is perfectly possible.

However, this could not be done except in the form of nitrate of soda, and, as I have already indicated to you, nitrate of soda made at the Muscle Shoals plant would cost more than Chilean nitrate of soda can be purchased for. Therefore, if the Government should dispose of 150,000 tons of Chilean nitrate now in stock in order to avoid the investment of fresh funds to the amonnt of $12,500,000 in the Muscle Shoals plant, and the Muscle Shoals plant should turn around and reproduce the 150,000 tons of nitrate of soda and place that in stock we should have then invested in fresh capital in order to operate the Muscle Shoals plant more than $12,500,000 instead of having made no fresh investment at all as contended by the administration.

The next vital matter in this situation is the old question of the demand for sulphate.

The CHAIRMAN. Is there any doubt in your mind, Mr. Washburn, that it was possible for the Government to manufacture in, say, a year's time the amount of 150,000 tons of this product?

Mr. WASHBURN. No; substantially that can be done.

The CHAIRMAN. You have stated it probably, but if you have I would rather you would restate it; at what cost to the Government at this time?

Mr. WASHBURN. I think our figures show at this time that the cost would be about $85 a ton.

Senator KENDRICK. What is the Government's estimate?

Mr. WASHBURN. I do not know.

Senator KENDRICK. It is $65 a ton, isn't it?

Mr. WASHBURN. I think they have made no estimate on the cost.

Col. BURNS. For the manufacture of sodium nitrate down there?

Senator KENDRICK. Yes.

Col. BURNS. We have made no estimate because that would be a war-emergency action. We would not propose to make a statement now in peace time of what it would cost for fertilizer purposes.

The **Chairman.** I was speaking about replacing this product which the Secretary of War is asking us to dispose of. The idea is to replace 150,000 tons that you would dispose of, and you would have to manufacture it, wouldn't you?

Col. **Burns.** We do not intend to manufacture 150,000 long tons of sodium nitrate. We maintain that that plant is able if called upon to manufacture within a year approximately within 150,000 long tons of sodium nitrate with certain modifications and conditions. We do not think it would be necessary to manufacture that during peace times. Inasmuch as we have a plant ready to do it we think the proper time would be to call upon the plant when the emergency arises; but we feel we would have a sufficient insurance in the form of sodium nitrate to carry us along in order to catch up with our program.

The **Chairman.** As I understand the Government requirements it is to have on hand a certain amount of these compounds. Am I mistaken in assuming that you are supposed to have on hand 300,000 tons of this product? I have heard that stated, but it may not be so; that that was the necessary requirement.

Col. **Burns.** I am pretty sure that the Secretary of War's policy in regard to that is this: That if we do not have a going plant we should have 300,000 long tons of sodium nitrate on hand as a war reserve. But if we have a going plant down there we can reduce the stocks of sodium by 150,000 tons.

Senator **Kendrick.** And your estimate is that 300,000 tons would amply meet your needs for 12 months, isn't it?

Col. **Burns.** Yes, sir; and give us a factor of safety of 25 per cent.

Senator **Kendrick.** And your arrangement in lieu of that is to have a sufficient supply on hand, or at least half the amount, and through the operation of this plant to then supply your needs as fast as required; is that it?

Col. **Burns.** Yes, sir; that is correct. We feel that with this plant we could keep 150,000 long tons of sodium nitrate on hand, and with that plant we have the further advantage that it should be increased or duplicated quicker than in case we did not have a going plant. I did not bring that out the other day because I thought the statement of what No. 2 plant could produce in a year would give you a picture of the situation. It is a complicated product, and if you wish it worked out we can give you the entire solution, but in general terms it means that that plant can produce 150,000 long tons in a year.

Senator **Ransdell.** And you could put in additional machinery to increase the output?

Col. **Burns.** Yes, sir.

Senator **Ransdell.** Very rapidly?

Col. **Burns.** Yes, sir; because the power to be produced by the Muscle Shoals Dam would run three or four plants, each one the equivalent of the plant that already exists there. It is a wonderful assurance of nitrogen fixation with that whole plant there.

The **Chairman.** The committee will now take a recess until 2.30 o'clock p. m.

(Whereupon, at 12.40 o'clock p. m., the committee recessed until 2.30 o'clock p. m.)

AFTER RECESS.

The CHAIRMAN. Mr. Washburn, you may proceed.

Mr. WASHBURN. Mr. Chairman, Dr. Milton Whitney, Chief of the Bureau of Soils, Department of Agriculture, appeared before you on April 21 and gave a great deal of interesting information on the art of fertilizing crops, relative merits of different materials and mixtures. There was a great deal in Dr. Whitney's statements to which no one familiar with the subjects under discussion could take exception. At the same time, it is to be noted that nowhere did this witness give any figures bearing upon costs or quantities; nor, I judge, did he consider that it was his part to do so.

There is practically no difference of opinion among those who are dealing with this subject as to the importance of fertilizer, and that it is tremendously important to have a cheap and plentiful supply. We do take exception, however, to some of the manifest inferences drawn from Dr. Whitney's generalizations. First, that there will be any such sudden and extreme cessation in the use of organic materials in fertilizers as to make it necessary to provide a great and increased amount of sulphate of ammonia to take the place of these organics. In any event, the sulphate to meet the demand is here.

The increased use of some of the organics as feedstuffs has been going on for a long time, and it has been somewhat accentuated during the last three years, due to abnormal, temporary, and accidental causes. The statements which we have made to this committee as to the increased use of sulphate of ammonia in succeeding years and the forecasts which we have based on these statements take these things into account. One would judge from the testimony of some of the witnesses that my contention is that organics will not be used for feeding purposes—such is very far from the truth. I have taken into account, I believe, to the full extent of what the facts will warrant.

The champions of the Government plan for operating Muscle Shoals have stressed particularly, and in effect have made it their principal economic argument for the necessity of operating that plant—that cottonseed meal will from this time forth rapidly disappear from the fertilizer market. Let us reduce the subject to figures and see whether it has any such serious significance as the Government attaches to it.

Of all the organics, cottonseed meal is the most important. The average annual volume of organic compounds exported from and consumed within the United States from 1912 to 1917 was equivalent to about 200,000 tons of nitrogen. Cottonseed products constituted 70 per cent of this amount. Of the whole amount of cottonseed meal, 25 per cent was exported, 40 per cent used as feeding stuff, 21 per cent used directly by the farmer as fertilizer, and only 14 per cent used in the fertilizer industry, and of that part which is used in fertilizer two-thirds is used by the farmer without any expense for transportation and without the cost of mixing by and profits to the fertilizer manufacturer.

This part will very slowly, if ever, be released by the farmer because it will be highly uneconomical for him to do so regardless of what price cottonseed meal may attain as a feeding stuff. We have, then, substantially only 14 per cent of the cottonseed meal produced in the country which will have any chance of varying in its application and use as between fertilizer on the one hand and feed on the other. This 14 per cent will inevitably swing back and forth in varying proportions from year to year between fertilizer use and feed use. In years when corn is high, for it is with corn that feeding stuffs compete, its use as a feed will be relatively great. With a normal corn crop and the normal price for corn, and particularly when there is a good cotton crop, and particularly when there is a good cotton crop, the relative use of meal as a fertilizer will be great. This has been going on for years. The minimum which goes into fertilizer in any year must always be a very substantial amount for the reason that only the bright yellow mean, in any event, can go into feed stuff, and the damaged, fermented, and dark-colored meal, being suitable only for fertilizer, will, of course, go there regardless of the relative market price in the two fields of use.

The Federal Trade Commission in its report on the fertilizer industry, page 59, says, summarizing its comments on this matter [reading]:

> Although the use of cottonseed meal as a food for stock has beeen gradually increasing it is probably that the actual tonnage used as a fertilizer material has not materially decreased, due to the fact that the proportion of the cotton seed produced reaching the oil mills is constantly increasing.

This is borne out if we take the ratio of cottonseed meal used as a fertilizer to the total quantity of fertilizer manufactured through the successive years; in 1904 the ratio is 3.2 per cent; in 1914 the ratio is 3.9 per cent; in 1917 the ratio is 4.6 per cent; in 1918 the ratio is 3.9 per cent. Now, if we compare the average figures from 1912 to 1917, just given out, with the figure of the disposal of cottonseed meal for the year 1918, we find that there was used by the farmers direct as a fertilizer 18 per cent in 1918 as compared with 21 per cent. There was used in the fertilizer industry 17 per cent in 1918, as compared with 14 per cent, leaving the total in fertilizer of 35 per cent in both periods.

It would be surprising at this time when corn has advanced to $1.35 per bushel from 60 cents in 1915, if cottonseed meal should not be used for feeding purposes. Furthermore, our last three cotton crops have been small. Small cotton crops and high corn prices are just the conditions under which we ought to expect this temporary swing of the use of organics more strongly toward the feeding stuff market than toward the fertilizer market. The statement which was made before your committee that the whole market for organic ammoniates is on the verge of being wiped out has nothing, in our belief, to support it when the matter is reduced to figures and to market conditions as they are known to those men whose life work is in the purchase and use of such materials.

The exaggeration involved in such a statement is clear, in view of the fact that a very large part of the organic ammoniates used in fertilizer are unsuited and impossible of use for feeding purposes. Furthermore, organics and Chilean nitrate are the only nitrogenous materials the home mixers and the dry mixers can use. And the 1½ to 2 per cent of potash and of phosphoric acid in cottonseed meal generally gives it 15 per cent more value than appears in the nitrogen.

One would judge from such statements that all those elements of control which guide every other industry in the world had been suddenly removed from the fertilizer industry, and that feeding stuffs could have an unlimited price, and that the agricultural world would turn suddenly from a material which has appeared in 98 per cent of its fertilizer for five decades, and admittedly of the highest effectiveness, to its complete abandonment.

The testimony of Dr. Whitney before you dwelt chiefly upon the proposition to launch the Government into the manufacture of a complete fertilizer containing not only nitrogen but phosphoric acid and potash. In this project its proponent states that the price of the product and the hardship which may be worked on legitimate private enterprise in carrying on this plan is a detail. Dr. Whitney laid before you the alluring prospect of the material known as ammonium phosphate—the manufacture of phosphoric acid by the electric furnace, treating it with ammonia to be made at Muscle Shoals, and eventually concluding as a feature of his electric furnace process the addition of potash.

The chief interest which the committee evidently felt in the matter grew out of the belief that the Agricultural Department had invented something of value, had possibly exclusive knowledge of it, and would be capable of getting a practical, economical industrial result. The material described to you by Dr. Whitney is already produced in thousands of tons per annum. The process he has described as in an experimental stage and promising, awaiting development by a Government bureau, have already been brought to commercial practicability seemingly without the knowledge of the Government. Private initiative and private capital have been at work for years upon every one of the processes; has expended thousands of dollars in the hands of the ablest men who can be found, working always under the necessity of producing something while better than what is now in existence must also be cheaper to produce. These private interests are entitled to the protection of their patents, without which there would be no incentive to undertake the long and expensive campaign from a mere chemical conception to commercial practicability, and therefore no benefit to society.

All of the things of which the Agricultural Department is dreaming not only exist but their ownership is lodged where it should be, in the only place, in my judgment, where they would be of benefit to mankind, and that is in the hands of private industry, rather than in the hands of a Government bureau.

As a practical example of what I mean, I may say that the American Cyanamid Co. is producing 30,000 to 40,000 tons of ammonium phosphate per annum. It is now engaged in erecting a new plant which will include all the improvements growing out of its commercial experience; and employing an electric furnace built as a result of discarding the type of furnace which the Agricultural Department imagines is so perfect and appropriate. It will be of interest for me to mention some of the fundamental patents which apply to this art. It is highly improbable that private capital would consider for a moment the giving of rights under these patents to the Government, particularly under the declaration that the price at which the Government would place its product on the market, and the question as to whether hardships would be worked to legitimate private enterprise, are merely matters of detail. Without these patents, which are fundamental, as to principle as well as covering process details, the Government could not manufacture this purely commercial product unless it shall take advantage of the high-handed proceeding of condemnation for which the bill now before you seems to provide. This illustrates the pleasing, lovely sort of competition to which private interests may be subjected when the Government shall enter industry.

This brings me to comment upon the criticism of inconsistency on my part in objecting to that feature of the present bill which gives this proposed Federal corporation all the powers enjoyed by the President under the nitrate section, No. 124, of the national defense act. In the national defense act there is given the right of condemnation of processes, but of necessity limited to matters vital to the national defense. The bill now before you, which is to create a Federal corporation to enter merchandising and manufacturing in competition with private interests, is to have extended to it the right of condemning anything which a competitor may have, even although it may have only a commercial value. I do not know wherein there is a stronger example in this whole connection of the injustice and of that dangerous thing which raises its head so frequently at the present time in connection with government which we know by the name of socialism. Personally, I think it resembles a thing which goes by a much uglier name.

It seems to be extremely difficult for the administration representatives to confine their analysis of the factors bearing upon the Government plan to figures. There is a constant reiteration on the part of the administration representatives of facts upon which there is no disagreement, so far as I know. The inference in too many cases is that the mere existence of these facts is a sufficient basis for placing the Muscle Shoals plant in operation and a sufficient basis for the Government entering industry and for other features of the Government plan. For instance, the letter of Dr. Lipman, director of the Agricultural Experiment Station in the State of New Jersey, introduced before your committee on the 21st of April, states that the market for ammonium sulphate in the United States is certain to expand very rapidly in the next decade.

Undoubtedly, but what of it? The world production capacity is 26 times what it was in 1914 and the United States 2½ times. The question is how rapidly, associated with the question as to what the productive capacity of the country will be if left to private industry. It is to the answer of these two questions that I have been lending myself before your committee. Broad generalizations may bring us to false conclusions. Dr. Lipman's letter devotes itself very largely to the question of whether sulphate of ammonia can take the place of nitrate of soda. It seems to me that is very much beside the question. The relative effects, advantages and disadvantages, and the natural place of sulphate of ammonia and nitrate of soda are no different to-day from what they were at any time in the past. The balancing of plant food of different kinds of nitrogen compounds is wise; the practice is the result of untold years of experience, observation; belief in the principle is well fixed in the minds of the farmers of this country. The belief expresses itself in a faith in certain proportions of the various kinds of nitrogen in a fertilizer. Within limits these proportions are affected by relative costs of these materials. Therefore, other things being equal, an increased use of sulphate of ammonia will bring about an increased use of nitrate of soda, in order to maintain the desired proportion of each, and to support this in a rough way on a scientific basis we have the example of the law of limiting factors, which I have referred to in earlier testimony.

Now, what could enter into this situation to displace nitrate of soda in any measurable degree by substituting sulphate of ammonia? Clearly only a great disparity in price. But the Muscle Shoals plant can not now and never will be able to manufacture at such costs as are comparable to the costs at which nitrate of soda can be laid down in the United States. You have testimony from independent sources, and of late compilation, showing that nitrate of soda can be laid down in the United States at costs substantially as low as the lowest estimates of the Government for making sulphate of ammonia at Muscle Shoals, notwithstanding that in those costs no figures are included for interest, nor taxes of any sort, insurance, workmen's compensation, etc.

This question of supply and demand can not be treated as a generalization. It is a matter of figures. Our contention is that when the figures are properly put together with reason, and in accordance with the laws of trade and industry, that they show that the supply of nitrogen of the various kinds and in accordance with the most desirable ratios will be ample. One of the Government witnesses criticized our figures for the future demand for nitrogen because in projecting the curve beyond 1920 we did not assume a constant percentage increase from one decade to the next. Materials are not used by human beings and can not be used in an ascending scale of a constant percentage, or anything like it. This was the trouble with the White diagram for future consumption prepared by one of the Government witnesses. One has only to examine the past to see that the law of increase is additive and not by geometric increase. To assume an increasingly ascending curve, which is equivalent to an increase by a fixed percentage, is not in accordance with the past history of the consumption of nitrogen, and if applied to the future not only violently changes the history of the past but leads to anomalous and impossible results for the future.

To illustrate this I will call your attention to what the effect would be of applying the percentage of 250 per cent and the percentage of 180 per cent for each decade, which are the percentages of increase from 1900 to 1910 in the one case, and from 1905 to 1915 in the other case, respectively, as figured out by the Government representatives. In 1930 we should have in the one case a consumption of substantially 1,500,000 tons of nitrogen, and in the other case about 800,000 tons. While, if we proceed in accordance with the law of increase in the past we should have 350,000 tons of nitrogen as the demand. If we should accept the Government estimate of 250 per cent increase for the decade from 1900 to 1910 as the percentage increase to apply to each decade up to 1950, we should in

1950 have as a consumption in this country nearly 20,000,000 tons of nitrogen, equivalent to 133,000,000 tons of nitrate of soda, which is about 44 times the present mining capacity of Chile. I merely mention this to show to what a ridiculous conclusion the principle of increase by such a curve would bring us.

This brings us to certain late criticisms of our cost estimates. You will recall that as a part of our testimony on April 10 we presented the committee tabulated estimates of cost, and in order that it might be clear to you wherein these estimates differed from the Government estimates, and in order not to make costs of production, with our authority back of them, public property, we accepted the Government figures in detail and set them down accordingly, changing them only to represent the present price or cost of materials and adding to the Government figures those items which the Government had left out of its estimate.

This revision has been commented upon by the Government witnesses in various ways. It was pointed out that statements which I have previously made to another congressional committee indicated that certain estimates we had made were only 5 to 10 per cent higher than certain estimates the Government had made. I fail to understand what that has to do with the case. The estimates were for the operation of the Muscle Shoals plant at about the time of the close of the war and were prices for raw materials and labor that then existed and included items only that were included by the Government in its estimates. The Government did not include in those estimates interest and depreciation, amortization, replacements, taxes, insurance, and a great many other things. In the same way, the Government at this time has not included most of those items, and neither do we, but we do insist that while the Government may operate this plant without charging interest and depreciation and taxes and insurance and other items of that sort, that it must have plant general expense and replacements, including betterments.

The Government takes issue with certain items of cost in the correction of their estimates which we have submitted to you. For instance, that we put limestone in at $2 instead of $1.50 per ton. To substantiate their figure of $1.50, two men were consulted who are actually quarrying limestone in quantities—one in Pennsylvania and one in Tennessee. The quarrying of limestone for chemical uses is a totally different proposition from quarrying limestone for ordinary commercial use. One is a selective process not only as to quality, which may be minimized in a quarry of suitable and uniform material, but there is involved also a very great wastage due to the fact that the stone must be furnished in screened 1-inch size in order to be fed to the rotary kilns which burn it into lime.

This creates a very large amount of fine material at the quarry, particularly in the stone characteristic of the region about Muscle Shoals. These screenings are practically waste and increase the cost per ton of the stone shipped. All previous estimates based upon conditions of labor and material as they exist to-day have, so far as I know, been in excess of $2, and we felt that the figure we put in was conservative. I would not mention the difference between the Government point of view and our own, as it amounts to less than 90 cents a ton of finished product, were it not that I want the committee to understand that our figures are the outgrowth of experience and knowledge of details, and this particular detail extends through years of experience in the very important matter of selecting, quarrying, and preparing limestone for the particular chemical use which it will have at Muscle Shoals.

There is criticism also of our estimate for steam, which we have taken at 60 cents per 1,000 pounds. The item is unimportant. It might have been forgotten without affecting the final figures materially, but the witness points out what he believes to be an inconsistency between our price for process steam and the figure which we insert for the cost of steam power, notwithstanding the fact that our cost for steam power is the same as the Government assumed cost for steam power. What the witness failed to recognize is that the cost of steam in the main power plant is not the same as the cost of steam produced in the process steam plant, 1 mile distant. In the power plant there is no handling of coal, which is dumped from cars into bins which are over the boilers, the coal descending by gravity into the boilers. The ash handling is practically automatic and without labor. The boilers themselves are of a more efficient type, greater in capacity, and the pounds of steam to the kilowatt will be considerably less than assumed by the Government witness.

In the process steam plant the coal is handled from the cars and elevated to overhead bins. There is no present means of ash disposal except the rehandling of it into cars and dragging it off. The labor in this small plant per pound of steam produced will be very much in excess of the labor in the power plant. Furthermore, the amount of steam set down as required for processing is the net amount required to carry out the proper chemical reactions, but the actual amount which the boilers are called upon to produce is very considerably in excess of this, due to leakage, condensation, and other causes. The corresponding Government figure for steam was about 35 cents per 1,000 pounds, instead of 60 cents, and would make a total difference in the cost of the final product of only 87 cents a ton. Again, this is not worth considering, but I do not want to have the committee feel that even on an item of this relative unimportance we are careless or oblivious to the details of manufacture.

It has been suggested by one of the Government representatives appearing before your committee that there may be some inconsistencies between an estimate furnished by us to the Government under date of December 28, 1918, projecting the cost of producing ammonium nitrate at the Muscle Shoals plant and the corrected Government estimate which we laid before your committee within the last few days. The inconsistency, as they see it, lies in their claim that in that estimate there was required $915,000 per annum for repairs, while in the corrected Government estimate, just referred to as having been furnished by us, there is a total of substantially $2,650,000 per annum covering repairs and replacements, including betterments.

An estimate must be judged by the things which it includes. The estimate of December 28, 1918, omitted a great many things which are known items of expenditure, such as administration, interest, depreciation, taxes, as well as the item of replacements. There would have been no point in including replacements as the estimate was for the bare cost of running a brand-new plant for the production of ammonium nitrate under a war emergency. A commercial plant involves a steady, long-time operation and self-interest in the matter of reduced costs of production as well as the pressure of competition forces, replacements, and betterments in the interest of economy. With this statement I think we are ready to examine the figures in detail and see to what extent the one set of estimates is inconsistent with the other.

The Government witness has pointed out that the $915,000 contained in the estimate of December 28 should now, by reason of change in costs of labor and materials, be 25 per cent more, or equivalent to, roundly, $1,150,000.

The item of replacements includes betterments, which it is now proper to enter in the present estimates, considering the purpose and conditions under which they are made, and should be added to those figures, giving a total, roundly, of $2,300,000. This is $350,000 less than the figure of $2,650,000, which covers the total repair and replacement items in the corrected Government estimate which we have furnished you. This is an inconsistency and would change our total from substantially $92 per ton to $90 per ton.

The inconsistency arises by reason of the fact that the Government has included for straight repairs a larger amount than we included in our estimate of the 28th of December, and, therefore, the additive item of replacements, while proper to be added to our estimates of December 28, is somewhat in excess of the amount which should be added to the Government estimates submitted to you.

The next figure which the Government criticizes is one for general factory expense. This was put in out of our experience and includes a great number of items, only a part of which were included in the Government estimates. They are definite and necessary items of expense, such as supplies for office, laboratory, yard, coal for locomotives, gas for automobiles, supplies for hospital, and heavy supplies, such as those required for the water system, etc. It includes also the pay roll for the superintendence and general office force; the departments of personnel, purchase and stores, traffic, records and reports, water supply, hospital and chemical departments, etc. As an example of the insufficiency both in numbers and wages as contained in the Government estimate of March 22, 1920, I would point out the pay-roll estimate for the raw materials and yards department. Here there are provided for only two switching crews. This would only be enough for a plant one-quarter the size of the Muscle Shoals plant, as we known from experience in our own plants.

Furthermore, we are criticized for putting in bagging expense, but it was our purpose to show what the material would cost bagged. If anyone wants the cost in bulk it is very easy to deduct the cost of the bagging.

We are further criticized for including interest on the additional $12,500,000 of fresh funds for which the bill before you asks. This is on the basis that the Government can dispose of $12,500,000 of nitrate of soda. I have already dealt with this, and from our point of view and, it would seem, as well from the Government point of view, this plant would not warrant the Government in disposing of $12,500,000 of nitrate of soda out of its reserve stock except by devoting it in event of war to a special purpose different from the one for which it was built and thus leave substantially half of it idle while fulfilling that special purpose.

Our same critic then proceeds to deduct $9 a ton sulphate of ammonia from our estimate because of the difference between the cost of steam power as compared with water power. This assumed difference of $9 is secured under the assumption that there is no interest charge to be made either against the steam-power plant or against the water-power plant. From the Government point of view, and the one carried through the whole estimate by the Government, as well as ourselves in making corrections of their estimates, we include no interest on money already expended and therefore no interest on steam power, but when it comes to figuring the water power without interest that is going too far in the direction of fanciful costs. If we figure no interest on the steam power and figure interest on the water power, there is substantially no difference in cost between the steam power and water power and therefore nothing to be deducted from our correction of the Government estimate, even if water power were to be substituted for steam power.

In regard to this matter of costs, I think it is useful to call attention to information given in the hearings before Subcommittee No. 5, Ordnance, of the Select Committee on Expenditures, War Department, House of Representatives, April 13, 1920. The Hon. W. J. Graham is chairman of this committee, as you know. I refer particularly to a letter addressed to the committee by Dr. Charles L. Parsons under date of March 25, 1920. Dr. Parsons was lately connected with the Mining Bureau of the Department of the Interior and was the expert sent abroad in charge of the investigations made by the President's nitrate committee. His mission was particularly to investigate the cyanamid process in comparison with other processes in use in Europe for the fixation of atmospheric nitrogen. He supplies an estimate of the cost of raw cyanamid of $46.79 in comparison with the figure which has been presented to you by the Government representatives of $31.10 per ton, or, if we increase the $31.10 by 25 per cent, which it is my understanding the later estimates of the Government show, we have Dr. Parsons's figure of $46.79 as compared with the latest figures placed before you by the Government of $38.87 and in comparison with our figure of $42 submitted to you in connection of the Government's estimate.

You will note that Dr. Parsons's figure is in excess of both the Government figure submitted to you and of our correction of the Government estimate, and, incidentally, you will note that our cost is very materially greater than the Government cost according to their latest statement to you. These costs, however, it must be borne in mind, have to do with the raw cyanamid. From this point on to the completed product, sulphate of ammonia, no one outside the American Cyanamid Co. has had any experience whatsoever, and from this point on to the completed sulphate of ammonia is where the widest divergencies exist between the Government's costs and our corrections of them. But to continue with Dr. Parsons's testimony, he says, referring to the same estimate which was submitted to you by the Government as their costs, and quoting [reading]:

> I would state that I have studied these figures carefully and obtained such information as I have been able to obtain in the short time at my disposal. I find these figures extremely difficult to analyze, as I do not know the basis for their calculations per day for labor, superintendence, amounts of material used, etc., with the exception of limestone, coke, coal, electrodes, and power. I have no hesitancy in saying, however, that there is no question in my own mind, after a careful study of the situation, that the figures given can not hope to be reached at the prices now prevailing, and that the cost of raw cyanamid produced at Muscle Shoals, whether operated by the Government or by a private corporation, would exceed the figures given by many dollars per ton.

His whole method of determining costs is very different from that employed either by ourselves or by the Government. He goes to an entirely independent source, namely, the largest carbide company in the world, to secure the principal item of cost entering into the manufacture of cyanamid, namely, calcium carbide. He, like the Government and ourselves, however, excludes interest, amortization, obsolescence, depreciation, legal and State taxes, Federal taxes, insurance, legal expense, general administrative expense, advertising, warehousing, transportation, and distribution.

In conclusion, in the matter of costs, we see no reason from anything which the Government has advanced why the figures which we have submitted to you should be modified, except as indicated, reducing the cost of sulphate when plant is operating full capacity from $92 to $90 per ton.

I should like now to take the last Government statement to you of its estimates of cost and see what it leads to under certain assumptions which appear to be reasonable and fair and logical. The Government has stated to you in its testimony on the 21st of April that their new estimates of the cost of sulphate made with water power and the present price of materials is $61, as compared with the former figure of $48. The Government does not include in that the following items: Interest on the water-power plant, amounting to $6; difference between their estimate of plant general expense and ours, $4.50; interest on the $12,500,000 asked for in Senate bill 3390, $3; replacements amounting to $5.75; reduction of royalties in Government estimate, $4.50; total, $23.75.

Adding these items to the Government estimate, we have a total of substantially $85, as compared with our total of the corrected Givernment estimate, less half the bagging cost, of $88. This will pretty clearly indicate to you the nature of the chief differences between the Government's estimate and our own.

We must not lose sight of the fact that none of these estimates can be reasonably or safely taken as representative of what the actual costs to the Government will be of producing the product at Muscle Shoals. They are, after all, strictly academic in their aspect and for the following reasons, which never have been called to your attention so far as I know:

The actual figures of cost will inevitably exceed the purely formal figures, which latter are the only ones which have ever been placed before you, and which from our own point of view, even on the assumption of the plant working at full capacity and being able to buy its sulphuric acid in the open market, leave a profit of only $2 per ton on the present market price of sulphate and a loss of $16 per ton on last year's prices.

Personally, I should not know where to find sulphuric acid for use in this plant. And certainly no corporation of which I have any knowledge would go into a venture of this kind without assuring itself of a supply of sulphuric acid. There is no estimate for a sulphuric acid plant, and if one had to be constructed to meet the full requirements of the ammonia plant it would mean an additional investment of $3,500,000 to $4,000,000.

I suppose it has not escaped you that these estimates are based upon the working of the plant to substantially its full capacity. Full capacity in ammonium sulphate would put on the market two-thirds as much actual ammonium sulphate as was produced in this country last year, and probably as much as was used in this country last year.

An absolutely brand new shoe factory could not start operations in this country and sell in addition to the regular output as many shoes as were used in this country last year, thus absolutely duplicating every pair of shoes that was used in the country. Suppose these shoes were also a by-product, bound to be produced anyway, no help for it, must be put on the market whether there was any need for them or not, it is not likely that a new shoe factory of the same capacity could operate to the full of its capacity. Therefore this shoe factory would be extremely fortunate, even under the Government's methods of figuring cost, if it could run to one-third capacity.

In the year 1919 everybody who wanted sulphate of ammonia received it, and the production was so far in excess of what could be forced upon the American market at substantially the peace-time price of $3.60 per hundred pounds that 100,000 tons were exported The by-product coke-oven industry at the beginning of this year of 1920 estimated the full of the domestic requirements, deducted it from the anticipated output, and found that there remained 100,000 tons surplus available for export. The attractive export price warranted an increase over last year's domestic price, but very considerably less than the export price. It is true that unexpected and extraordinary strikes, notably the railroad strike, has up to the present time slackened the anticipated output. However, there will be sulphate sufficient to supply the wants of all domestic users unless further adverse conditions develop.

Is it reasonable to anticipate, then, that the Muscle Shoals plant would run to exceed one-third capacity? According to our estimates of December 28, 1918, to which I have already referred, it would cost fully one-third more a ton to produce at Muscle Shoals when the plant is running one-third capacity than when it is running full capacity, and if we add to the costs of full capacity one-third we not only wipe out every element of profit which even the rosiest of Government estimates have assumed, but, according to what we consider to be the costs, exclusive of items of interest on money already invested, amortization, taxes, etc., there will be a deficit amounting to one and a half to two million dollars per annum, assuming the product to be sold at the present market price of $4.50 a hundred pounds.

What are the determining factors in this situation? We may classify them as follows: (*a*) Economic, (*b*) military, and (*c*) political.

On the economic side it is contended: First, that the Muscle Shoals plant will produce fertilizer and rescue the farmer from the exactions of the Fertilizer Trust and free him from dependence on Chilean nitrate. We have shown that the material which it is proposed to produce at Muscle Shoals constitutes only 10 per cent in cost of all the materials used in fertilizers; that it is proposed by the Government to sell the Muscle Shoals product to the fertilizers manufacturers, from whom the farmer will have to buy it; that it will not lessen the demand for Chilean nitrate, but will increase rather diminish the use of it.

Second. That there is a great need for sulphate, which only can be supplied by operating the Muscle Shoals plant. The facts are that the productive capacity of the country in sulphate is two and a half times what it was at the outbreak of the war, and sufficient not only to supply every domestic requirement, but to have available from the surplus large quantities for export in the future, as there are available large quantities at the present time.

Third. That to place the Muscle Shoals explosives plant in operation is to salvage a $62,000,000 plant for the Government, while the facts are that the normal peace-time value of that part of the plant which would be used under the Government plan is only about $15,000,000, and that it will require not less than $38,000,000 of fresh capital to place this $15,000,000 plant in operation.

Fourth. That the Government will enjoy a net profit from the commercial operation of the plant. We believe that we have shown that even when there is excluded from the Government costs interest on moneys already expended, amortization, obsolescence, depreciation, local and State taxes, Federal taxes, insurance, legal expense, and advertising that there will be no profit, even under the assumption of the plant working at full capacity, and that on the basis of its working on one-third capacity there will be a deficit in out-of-pocket expenditure of over $1,500,000 to $2,000,000.

Fifth. That it is necessary for the Government to operate the plant for the purpose of developing the art of manufacturing fertilizer. The facts are that the very products which are set forth by the administration as new and unique and which are to be experimentally developed by the Government at Muscle Shoals are being manufactured in large quantities; and additional plants are being erected employing the worked-out principles that are merely Government dreams; and that the patents covering these processes are exclusive and the property of private parties.

Sixth. That it is necessary to build the Muscle Shoals hydroelectric power plant to supply power to the Muscle Shoals nitrate plant, when the facts are that the existing steam-electric plant is of ample capacity and will cost the Government no more for operation than the proposed water-power plant.

On the military side it is contended: First, that it is necessary to promptly begin the operation of the Muscle Shoals plant to preserve it from destruction. The administration plan contemplates that 80 per cent of the acid plant, roughly a half of the whole plant, will remain indefinitely in idleness, and as soon as the water-power plant can be completed the steam-electric plant would become idle. The facts are under any conceivable plan a very large part of the plant will of necessity remain in idleness until it is required to its full capacity for the particular purpose for which it was constructed, namely, the manufacture of the single material, ammonium nitrate, for military purposes. We believe the facts are, furthermore, that the whole of the plant can remain in temporary idleness for a period of from 5 to 10 years under proper care and inspection with less deterioration than would be involved in its use.

Second. That in case of war it would take a prohibitory length of time to place the idle plant in full operation. Experience has shown with this very plant that it would be practicable to place the whole plant in full operation within a period of not more than four months.

Third. That 150,000 tons of nitrate of soda now held as a military reserve by the Government can be disposed of when the Muscle Shoals plant shall be placed in operation. We have shown that it would take this plant a year to produce the equivalent of 150,000 tons of nitrate of soda; that it would require a very great additional expense in the matter of plant and equipment and cost of operating new processes in order to do this and deliver it to the various powder plants; and that such a divergence of the Muscle Shoals plant from its intended war purpose would result in shutting down half the capacity of the plant because there would be no use for the ammonia therein produced.

Fourth. That the processes by idleness would become obsolete. This we submit is a comparative matter of indifference, as the plant by its present processes produces a product of exceptional superiority; and under any circumstances the costs at this plant would not be increased by reason of improvements which might otherwise here be made in the process.

On the political side it is contended: First, that the Government operation of the Muscle Shoals plant will not destroy nor discourage private industry.

The by-product coke-oven industry, which hopes to attain to a capacity of 1,000,000 tons of sulphate per annum by the year 1925, unless there is adverse legislation, such as the proposed Senate bill No. 3390, will be seriously affected by the Government operation of the Muscle Shoals plant in the production of sulphate. The discouragement of this industry means limiting the otherwise available supply for war uses of by-product materials associated with ammonia and of far more importance than ammonia or the sulphate of ammonia. It discourages the conservation of approximately one-third of the heat units in coal coke for metallurgical and domestic purposes.

Uncertainty, discouragement, and loss will inevitably result to the great fertilizer industry of the United States by the Government entering the fertilizer field. The discouragement of this industry, upon which the entire agricultural interests of this great country depend will have a serious effect and involve losses to the farmers far exceeding any benefit which the Government-operated plants could possibly hope to secure.

The announced intention of the Secretary of War to put the Government on a grand scale into the business of generating, distributing, and selling electric power will bring discouragement to and check future developments of central-station power companies all over the United States.

The announced purpose of the administration plan to produce cyanamid fertilizer, incidentally a right which the Government does not possess, and sell it to the customers of the private cyanamid manufacturers, and the announced purpose to pay one-third to one-half the royalties provided for in the contracts with private parties under which the Muscle Shoals plant was constructed would mean a very serious crippling of the present manufacturers of cyanamid.

Second. That the Senate bill No. 3390 proposes a Federal corporation. We believe the truth is that the passage of this bill will start the nationalization of the fertilizer industry, both domestic and foreign.

It starts the nationalization of electric power plants, generation, distribution, and sale of electric power. It starts the nationalization of quarries. It starts the nationalization of laboratory and experimental plants for furnishing nitrogen products to the United States and others. It starts the nationalization of the so-called self-sustaining Federal agency. It eliminates the civil-service law in Government undertaking. The board of directors have power to appoint, define duties, fix salaries, and dismiss officers and employees.

The bill provides for the appointment and removal of the directors at the pleasure of the Secretary of War. It provides directors who are interested financially in the corporation only to the extent of the salaries which they may receive, and such salaries as the Secretary of War may fix.

It places Government property at a value of $125,000,000 in charge of a corporation without any obligatory return to the Government on the use of the investment.

It relieves the Treasury Department of control of the financial affairs of the corporation and provides that the Secretary of War, who appoints the directors, shall be responsible for auditing the accounts of the corporation.

The bill permits the directors, by authority of the President, to condemn lands, materials, minerals, and processes, patented or otherwise useful in the manufacture of fertilizers and other useful products, by water power or any other power.

The CHAIRMAN. Col. Burns, are there any questions you desire to ask Mr. Washburn now?

Col. BURNS. Mr. Chairman, I do not believe it is going to serve any useful purpose to discuss this whole matter further. We have presented our case, and we have studied it very carefully, and we fully believe that the case as we have put it forth is pretty close to the correct one, and that it would just be hashing over and over again what we have already said, if we attempted to rebut what Mr. Washburn has again put before you. So I think there is no sense in going on with our hearing any further. I will, however, report to my superiors so that if they care to have us add anything further we may ask your permission so to do.

The CHAIRMAN. While Mr. Washburn is here, I wanted to ask this question: As I understand the figures given by Mr. Washburn to-day, there is not as much difference in the figures of cost as there was in the beginning, is there, Colonel?

Col. BURNS. No, sir; there is not, and it should be remembered that we admit in our figures that we are not taking into consideration the interest on the money. We have always maintained that stand.

The CHAIRMAN. The committee has accepted that from the beginning.

Another question I wanted to ask you while Mr. Washburn is here in this: Mr. Washburn, in his statement, said the first time he appeared before the committee, and he has also to-day restated that by the use of this product—the compound to be manufactured at Muscle Shoals—it would only increase the use of Chilean nitrates; that we can not hope to eliminate the purchase of Chilean nitrates even if the Government should go into this enterprise and manufacture the product which you have undertaken to produce. Is that your view point, Col. Burns?

Col. BURNS. To a certain extent, it is our view point, and to a certain extent it is not. As we have always stated, there would be a market for a certain amount of nitrate of soda, even though that plant would be operated; we could not, and I do not think it would be good policy to try to put nitrate of soda out of the market. But his principal point in his first statement was that ammonium sulphate could not be used interchangeably with sodium nitrate in mixed fertilizers. As I understand him to-day, he recedes from that position, and is willing to admit that ammonium sulphate can be used interchangeably with sodium nitrate to a greater extent in mixed fertilizer. If I am not correct in that, I would like to have Mr. Washburn correct me.

Mr. **Washburn**. The principles which govern the relative use of ammonium sulphate and nitrate of soda are so old with me and have been so much a part of our outlook on the business that it would be most unnatural for me at this time to change my views or to express one view one day and another view another day. If it were a new situation that were brought up to me, I might have formed an opinion and a false one and have corrected it, but what I had in mind and what I tried to elucidate was this—

That nitrate of soda has a natural place in which its cost, its plentifulness, its peculiar action in the soil, its ability to be used in home mixing, its ability to be used by the dry mixer, the ability to buy it in small quantities, and one thing and another of that sort, and particularly and more than anything else, the value that it has for strewing purposes as a surface fertilizer has given it a place relative to sulphate of ammonia that it has held for a number of years, and that its law or place is expressed in the fact that it constitutes in fertilizer a certain percentage of ammonia or a certain percentage of the nitrogen.

Now, if we encourage the use of a greater amount of nitrogen through the sale, we will say, in one way—chiefly of sulphate of ammonia—the influence will be to increase the use of nitrate of soda because there is every reason for maintenance in the future of that proportion of nitrate of soda that has been used in the past. So that at any time—that is one of the fundamentals in our business—we encourage the additional use of almost any kind of fertilizer materials it tends to carry on and increase the use of other materials.

Now, so much, then, for the general tendency of the additional use of sulphate of ammonia upon nitrate of soda.

There is another question involved, and that was whether sulphate of ammonia would drive out nitrate of soda. There is a natural place to which nitrate of soda will very strongly cling under any circumstances, but there is a field of variation between the relative quantity of nitrate of soda and of sulphate of ammonia that will swing back and forth, dependent upon the price of sulphate of ammonia on one hand and of the nitrate of soda on the other. But we can not expect that sulphate of ammonia, by reason of low price—now, I mean relatively low to the advantages of the two—but there is no hope that sulphate of ammonia, by reason of low price, will drop to a point so much cheaper than nitrate of soda will be furnished to us as to drive out nitrate of soda for that reason, because you have presented to you here from two rather low and seemingly reliable sources the fact that nitrate of soda can be laid down in this country at costs just as low, and, in fact, from our figures considerably lower than the Muscle Shoals plant could produce sulphate of ammonia, and lower than sulphate of ammonia has ever sold, except at one period in its history.

Therefore, to answer your question, Colonel, I see no prospect of sulphate of ammonia driving out nitrate of soda because of any increased production of sulphate of ammonia, and I see that if we encourage the additional use of the one kind of nitrogen known as ammonium nitrogen, if we follow the history of 50 years past, it will naturally encourage the additional use of nitrogen of soda. That was what I tried to convey.

Col. BURNS. Is it not a fact that the proportion of nitrate of soda that is used in mixed fertilizers is constantly decreasing, and that the proportion of ammonium sulphate that is used in mixed fertilizers is constantly increasing; in other words, that proportion you speak of is a dwindling proportion?

Mr. WASHBURN. You must take into account there, it would seem, not only the quantity that is used in mixed fertilizers, because when you come to take the relative quantities of sulphate of ammonia and nitrate of soda in mixed fertilizers you get 22 parts of sulphate of ammonia and 16 parts of nitrate of soda, relatively. But when you come to take the total quantity of nitrate of soda used, because that which is used for top dressing is usually a fertilizer just as much as the other, those things are reversed, and we get 22 parts of nitrate of soda to 17 parts of sulphate of ammonia.

Now, there is a slightly changing proportion in the amount of nitrate of soda in relation to the amount of sulphate of ammonia, and that is taken into account in our studies and in the production that we made of the future quantity of nitrate of soda and the future quantity of sulphate of amonia that would be used. Whatever the law was in the past, that law we have projected into the future; and if there is a decreasing amount of nitrate of soda with reference to sulphite, we show that decreasing amount.

Col. BURNS. Of course, that proportion, as we see it, is a constantly decreasing one. But the big point in reference to ammonium sulphate at No. 2 plant is, Can the market absorb it without interfering with other industries? We appreciate that Mr. Washburn has got one point of view, and we appreciate that the department has got another point of view, and it was in an effort to get an unbiased opinion that we asked Dr. Whitney to come here. As I recall Dr. Whitney's testimony, it is to the effect that the market does exist for the products of No. 2 plant, as outlined by the War Department program; and the rest of it, of course, is just going around the main issue.

The CHAIRMAN. Dr. Whitney stated emphatically that there was a market for all of it.

If there are no further questions, the committee is very much obliged to you, Mr. Washburn.

To-morrow the committee will hear Dr. Atkeson, who is associated with the grange, and Mr. Bower, of the Farmers' Union, and then we hope to close the hearings. It will take a few days to have all the hearings printed. Nearly all the statements are yet to be printed, and then we will have to wait a few days in order to allow the members of the committee to go through the hearings, and then the committee will hold a meeting for the purpose of disposing of the bill.

We are very much obliged to all of you gentlemen.

(Thereupon, at 3.45 o'clock p. m., the committee adjourned, to meet to-morrow, Wednesday, April 28, 1920, at 10.30 o'clock a. m.)

PRODUCTION OF ATMOSPHERIC NITROGEN.

WEDNESDAY, APRIL 28, 1920.

United States Senate,
Committee on Agriculture and Forestry,
Washington, D. C.

The committee met at 10.30 o'clock a. m., pursuant to adjournment on yesterday, Senator Asle J. Gronna presiding.

Present: Senators Gronna (chairman), Capper, Keyes, and Ransdell.

The Chairman. The committee will come to order. To-day is really set aside for the farmers' organizations to be heard, and we will first hear Mr. Marsh, who only wants a few minutes; then we will hear Mr. Bower, and Dr. Atkeson can be heard later on.

Mr. Marsh, you may come up this way so as to be near the stenographer. Please give your name and official connection to the reporter.

STATEMENT OF MR. BENJAMIN C. MARSH, SECRETARY AND DIRECTOR OF LEGISLATION, FARMERS' NATIONAL COUNCIL, BLISS BUILDING, WASHINGTON, D. C.

Mr. Marsh. The Farmers' National Council, as I think the members of this committee already know, is a special union of leading National and State farm organizations to carry out their legislative program adopted here at the Farmers' National Reconstruction Conference, held in January, 1919.

In appearing this morning on the pending Wadsworth bill, I want to say that this council has not taken a specific vote upon this measure, but their reconstruction program stresses the fact that agriculture has got to be made profitable, which it is not to-day; and in advocating the principles of this legislation I do so on behalf of the Farmers' National Council, because in our judgment the fertilizer question is a very serious one, and we feel that the principles of the Wadsworth bill will help to make farming more profitable.

I would like to read in two or three statements from official reports, if I may, explaining our position, before taking up, only in a general way as a summary, as I can not go into details, the principles of this legislation.

The Chairman. There is no objection to that. You may proceed.

Mr. Marsh. The Department of Agriculture made a report, Bulletin No. 798, from the Bureau of Soils, of which Mr. Milton Whitney is chief—and I believe that Mr. Whitney appeared before you in favor of this legislation—the said bulletin being entitled "A Survey of the Fertilizer Industry," by Dr. E. A. Goldenweiser, from which the following statement is quoted, the bulletin being issued under date of October 20, 1919 [reading]:

> The fact that from three-fourths to seven-eighths of the mixed fertilizer sold to farmers consists of inert matter which does not contribute to the fertility of the soil, but on which freight must be paid and which must be ground and bagged and transported, is one of the fundamentals in the fertilizer industry. If a means were devised by which farmers could buy practically undiluted plant food and make up their own mixtures, an enormous saving would be effected, and any method that would decrease the amount of inert matter carried in fertilizers would be of great benefit to the agriculture of the country. The quantity of filler used is only a minor phase of this problem, but perhaps the part of it which is most easily susceptible of improvement while the present general methods prevail in the industry.

In the report of the Federal Trade Commission on the fertilizer industry, issued of date August 19, 1916, made to the President of the United States, of course, the statement occurs [reading]:

> The economic importance of the fertilizer industry, which embraces the production and sale of various fertilizer materials, as well as the manufacture and sale of prepared or mixed fertilizers, is shown by the fact that the value of all commercial fertilizers consumed in 1914 was in excess of $150,000,000.

Of course, Mr. Chairman and gentlemen of the committee, prices of labor and material have gone up since then, and the best estimate that we can make is that the price paid for commercial fertilizers—and this an estimate that we do not put out as official—must be in the neighborhood of $300,000,000 to $350,000,000 at present. I think that is correct, but perhaps there are some gentlemen here who have more careful estimates on that matter.

This report of the Federal Trade Commission goes on to say [reading]:

> Farmers' prices of fertilizer materials for cash purchases in carload quantities have compared favorably with wholesale prices, but farmers' credit prices have often been excessively high.

There seems, however, to be virtually a monopoly of this business, or substantially a monopoly, for the Federal Trade Commission reports that while [reading]—

> the most of the fertilizers used in this country are purchased in mixed form and not in the form of materials. In the mixed fertilizer industry there are about 800 concerns operating some 1,200 plants, but the seven largest companies, with their numerous subsidiaries and affiliated concerns, control more than 58 per cent of the total output. The two largest sell annually over a million tons each, and in the aggregate about 34 per cent of the total output.
>
> The prices paid by farmers for mixed fertilizers have been high in comparison with the cash value of the constituent elements, partly because of credit conditions and the expensive distributing methods of the large fertilizer companies; for these reasons also the profits of the large companies have not been large.

I can hardly harmonize these two statements, but apparently the point is that somebody besides the large companies, which have made a considerable profit, have been making a big profit out of these mixed fertilizers, out of this mixed fertilizer business as it is.

But the commission says [reading]:

> Farmers having the cash and the initiative, by buying the materials and mixing them at home, have usually been able to save from $4 to $8 a ton.

That would seem reasonable if the farmers are paying, as seems to be the case, for fillers for mixed fertilizer the same price that they pay practically for the essential ingredients of the fertilizer.

Of course, Mr. Chairman, there have been bills introduced in the Congress, and I think you have had hearings in connection with the investigation of commercial feeds on the question also of mixed fertilizers. But I understand that there has been no conclusion reached on the subject, and no legislation has been enacted at all by the Congress to compel the manufacturers of commercial fertilizers to stamp upon the containers, whatever they may be, sacks or otherwise, the ingredients of the commercial fertilizers. It would seem a very reasonable thing to do.

I do not need to go into any detail before this committee, and you will be grateful to me for not doing so, as to the very precarious condition of agriculture in this country to-day. And in appearing on behalf of the principles of this measure we do so because we frankly feel that we are in great danger of having to write down the year 1920 as a starvation year, not only in America but in the world, from a threatened shortage of wheat, which is not so directly affected by the fertilizer proposition as are other feed crops.

We are not at all afraid of the charge that it is an experiment in Government ownership. The only test that we apply to any proposal is this: Will it be of real advantage to the American people—and we make it broad—and, more specifically, of advantage to the American farmer? We believe that it will be, because we can not conceive how it is to the advantage either of the American people or of the American farmer, who is primarily to be considered in this connection because he has got to render the great service of increasing production—I say we can not see how it is to the advantage of the farmer or of the general public to have a monopoly in the production of the essential ingredients of fertilizers.

The CHAIRMAN. Let me see if I understand you, Mr. Marsh. You would advocate the Government taking a more active part because of the emergency rather than as a matter of policy at this time; is that your position?

Mr. MARSH. That, I think, would be the strongest argument at this time. It does not open up the whole question of Government ownership, which is not involved at this time in this bill at all, but it is rather with the idea of meeting the situation existing in this country, which is accentuated by the threatened food shortage throughout the world, knowing perfectly well that we are in a more critical condition to-day than at any time during the war, because we have not the same incentives to sacrifice.

The CHAIRMAN. You have undoubtedly read a great deal of foreign literature, Mr. Marsh, and I would like to ask you what are your conclusions as to European countries being able to supply themselves with food without calling upon America to help them?

Mr. MARSH. Well, Mr. Chairman, I thank you for the compliment. It reminds me of my college president's statement, that a recommendation is what you are supposed to live up to. I have not had a chance to read all of the foreign literature on the subject, but I will say this, that for several weeks I have been getting together data on this question of foreign production of foodstuffs, as well as our own production, and I am feeling rather blue from the information I have been able to get together.

Senator **Ransdell.** Please state briefly why you feel blue. Give us a summary of the facts on which you base the statement that this will probably be a starvation year, as I think you referred to it.

Mr. **Marsh.** Senator Ransdell, I have just handed to Senator Gronna a letter from the Secretary of Agriculture on a subject on which we hope there may be a hearing within a few days. I have not all those figures in mind, but I think they will come up, and I think we have got to face this question of whether or not we will have enough food to go round. Briefly answering your question, however, it looks as though we were going to be 300,000,000 to 350,000,000 bushels of wheat short in this country. It looks that way now. Nobody can say what the reduction in acreage of spring wheat is going to be. There is probably going to be a reduction in acreage of rye, barley, corn, and perhaps of some other food staples. I am not taking up cotton, because I am discussing chiefly the food question at this time. But I know that the figures we are getting in indicate a very serious situation.

Senator **Ransdell.** Is that partially due to a shortage of labor, to so many laborers leaving the farms?

Mr. **Marsh.** I am coming to that. I think it is in part due to a shortage of labor, but that shortage of labor on the farm is only another way, it seems to me, of stating the fact that the farmers are not getting enough for their farm products. The minute a farmer can compete in the matter of paying wages with the subsidized manufacturer or with the manufacturer who is making profits of 50 per cent to 100 per cent or even 500 per cent over and above all costs, including wages—I say, the minute the farmer can get enough for his products to compete in the paying of wages with the city manufacturer I think the labor problem, so far as the farm is concerned, will be solved. Despite the altruistic motives of some people and the lure of the great white way, as some people refer to the matter, the average man will go where he can get the most money for the least effort. I think that is the determining rule in the matter of where people will work and where they will stay. It may be somewhat an old-fashioned viewpoint, but I am not discussing the relative ethics of the situation. The labor situation is a serious one, but so far as agriculture is concerned it is more largely due to the fact that farming has always been a most hazardous industry and that the farmer has been made the goat of our economic system. But he is not going to continue in that position.

A man who has been out through the West and talked with scores of farmers, as I did in January and February, tells me that the farmers and their wives and children have worked hard during the war—and there was no lack of patriotism and no desire to profiteer, and some broke even and some made just a little, but he says that they are not going to keep it up. He tells me that they ask the question: What is the use of keeping this up? We are going to raise enough for ourselves, but we are not going to individually assume the responsibility for feeding the world. I do not mean to say that the farmer is taking a narrow or unfair viewpoint. I do not think it is that. I think the farmer is waking up to the need for a great many fundamental economic changes in our financial, land, and transportation systems in this country. But I do know this, that if the farmers are assured of a fair return, and are assured, or have reasonable prospects, of getting such prices for their products as that they can afford to take the risk of hiring labor at current wages paid in the cities, we will have no trouble in getting a sufficient acreage planted in farm products. That is our opinion, and I think you gentlemen will agree in that opinion—that we have to face the proposition this year that the farmers have—and I will present figures at some other hearing if you ask for them, but will not interfere with the regular line of this hearing—I think if the farmers were assured of that situation, of being able to pay current wages, that the acreage of spring wheat, and of rye, corn, and of oats, and of barley, would be largely increased. I think we have got to do it, too.

Getting back to this proposal: Frankly, we feel there has been a lot of money wasted on these two plants at Sheffield and Muscle Shoals, but that is not the question at issue here. The question is, if we understood it correctly, Shall a private concern, which seems to have very entertaining ramifications into the commercial fertilizer manufacturing business, be permitted to maintain control of these plants, or shall the Government undertake the manufacture of this one of the three essential ingredients of fertilizers? I am not using technical language because I do not know the subject well enough to attempt to do so, but I know nitrogen is one of the essential ingredients for fertilizers; and shall the Government undertake the manufacture of nitrogen in order to enable the farmers to get their fertilizers at a more reasonable price? As I understand it no actual outlay by the Government will be necessary, no additional outlay I mean, or at least a very small amount if any, if the Government is authorized, as provided in the Wadsworth bill, to sell 175,000 tons of the product of this plant already on hand. I understand that will be sufficient, so that there will be no large appropriation necessary.

The CHAIRMAN. You mean 150,000 tons.

Mr. MARSH. Well, I understand it was 175,000 tons. I am glad that you have corrected me, and that is all to the good, if it is 150,000 tons, because it will require a lesser outlay.

Anything that reduces the cost of any commodity or material or supply which the farmer has to buy encourages the farmer. If the Federal Trade Commission is correct when they say that the farmer having the cash and the ability by buying materials and mixing them at home will be able to save from $4 to $8 a ton; if the farmer was able to do that in 1914, now considering the increases in prices that have taken place since that time, the farmer would probably be able to save, roughly speaking, from $8 to $16 a ton, which is quite a considerable saving. That is an estimate on my part based upon the relative purchasing power of money in 1914, the year covered by this report, and the purchasing power of money at the present time. So we advocate this proposition, not as the final solution of the fertilizer problem but as a measure, if you please, as an experiment which we really owe to the farmer to make, subject to close supervision.

Now, as to how the farmer is going to get phosphates and how he is going to get potash, phosphates, and potash; this bill, if I correctly understand it, does not touch that question at all. These are essential ingredients. I think this bill should be passed—and when I say I think this bill should be passed I mean I think the principles of this bill should be incorporated in legislation. I do not know whether the phraseology of the bill is correct or not, but I want to speak to the principles of the bill rather than to the phraseology. When we get this nitrogen we still have to get two other essential ingredients of fertilizer which need to be covered. I do not know what the plan of the committee is in respect to this.

Will the corporations which are manufacturing those two ingredients and distributing them in commerce for fertilizer purposes, will they be made subject to any control, or are they going to say: Thank God, the farmers are going to get nitrogen cheaper and therefore we should raise the prices of our two ingredients. Therefore I make the suggestion, and it must be only a suggestion, as my time is limited here now, that it would seem feasible to ask at least a survey by some Government agency, such as the Federal Trade Commission, at a very early time, of the practices of manufacturers of phosphoric acid and phosphates for commercial fertilizers, in order that they may be brought under control, too, because I imagine they are not falling behind in the great national game of manufacturers and corporations in the matter of profiteering.

Senator Ransdell. You would not leave out potash, would you?

Mr. Marsh. No; I mentioned potash.

Senator Ransdel. You said phosphate and you meant potash, did you?

Mr. Marsh. Yes, sir. I thank you if I misspoke myself. These two other ingredients ought certainly to be brought under immediate control or under immediate investigation anyhow. I am not advocating the fixing of prices because the farmers' unfortunate experience with that matter makes the fixing of prices not a very happy prospect.

That is practically all the statement I want to make, Mr. Chairman and gentlemen of the committee. But I want to assure you we think this is a limited measure of relief to the farmers in the way of getting fertilizers cheaper, and also in the way of the preventing of another big corporation or monopoly growing up and which will produce something the farmer has to have for which it can charge him an exorbitant price.

The Chairman. Any questions, gentlemen of the committee?

Senator Ransdell. I have none.

Senator Capper. I do not wish to ask any questions.

Senator Keyes. I do not believe I have anything to ask.

The Chairman. We will now hear Mr. Bower. Please give your name and official position to the stenographer, and you may make your statement in your own way.

STATEMENT OF MR. R. F. BOWER, CAMPBELL, VA.; NATIONAL BOARD OF FARM ORGANIZATIONS, WASHINGTON, D. C.

Mr. Bower. Mr. Chairman and gentlemen of the committee, I am a member of the National Board of Farm Organizations, representing the Virginia Division of the Farmers' Union. I am a member of the executive committee of the Virginia Division of the Farmers' Union, and I am the Washington representative of the National Farmers' Union.

Gentlemen of the committee, we wish to impress the committee with the importance and utmost significance of the legislation which you are considering. The representative of the American Cyanamid Co., who has been before this committee, has made claim to a partnership existing between his company and the United States Government. The thought that we wish to have in the committee's mind in considering this matter is the basic partnership not only of this Government but of all Governments with agriculture, and it is on a basis of this partnership we believe you can most efficiently consider the question before you. I do not think I can put into better words the fundamental truth of this partnership than those in which it has already been expressed to this committee by the Secretary of War, and I want to quote at this time his statement. He said [reading]:

> I think probably I need not say this, because I think everybody knows it, but history shows that every nation which has disappeared out of the civilization of the world went out by one or the other of two courses: It was either vanquished or destroyed by military processes, or it exhausted its soil and had to move. So far as I know, there is no exception to that in the history of nations.
>
> Therefore, what we have to deal with here is a plant which is addressed to the protection of the United States against either of those courses—either its military overthrow or its agricultural exhaustion. (Hearing before Committee on Agriculture and Forestry, United States Senate, on S. 3390, Mar. 22, 1920, p. 8.)

Theodore Roosevelt, in the Outlook of October 12, 1912, page 295, had this same thought in mind when he said [reading]:

> I have always been deeply impressed with Liebig's statement that it was the decrease of soil fertility, and not either peace or war, which was fundamental in bringing about the decadence of nations. While unquestionably nations have been destroyed by other causes, I have become convinced that it was the destruction of the soil itself which was, perhaps, the most fatal of all causes.

With this idea it is our desire, and we have followed it consistently in our study and expressions on this subject, to differentiate this development and its possibilities from so much of the irrelevant discussions and minor considerations such as persons, processes, and unfortunately, some politics, which have beclouded it.

We do hope that we will secure your interest in our statement and that you will have patience to hear fully what we may have to present, for the reason that in all the discussions of this question since 1916 you have had chemists, scientists, and business interests all presenting their viewpoint, but the farmers' side of this case has never before been presented to Congress, nor have they been represented on any of the commissions or committees that have studied this matter.

There are only two methods by which the present unrest in the country, due to extortionate prices, can be allayed—increased and cheaper production, and more direct, more efficient handling of the products after being produced. The agricultural situation is such that cheaper production can not be expected at this time unless there are fundamental changes in the factors of production. As an illustration of this, I should like to insert in the hearing at this point an article from the Wall Street Journal of March 1, 1920. However, I will only take the time of the committee to read three paragraphs of this article, but I ask that it all may be printed in the hearing.

(The article referred to, from the Wall Street Journal, is here printed in full in the record, as follows:)

FOOD SUPPLY AND FAMINE.

So long as the war was on food was a subject of the most anxious thought. The cause for that anxiety did not pass away with the cessation of fighting, and a world famine is even yet a possibility.

Sir James Wilson, a British statistician of international reputation, calculates that exporting countries will hold 344,000,000 bushels of old wheat on August 1, 1920. This is half the normal import requirements. To find this supply, however, he was obliged to count on Russia, Roumania, and India. The Indian harvest, to be gathered in April, now appears promising. Russia and Roumania are doubtful.

Canada and the United States are still the world's almoner, and the outlook here is not good. There was a mistaken propaganda emanating from Washington last autumn to reduce wheat seeding. This and the labor supply, aided by bad weather, resulted in an area of less than 39,000,000 acres of winter wheat compared with 50,000,000 the year before. The present acreage is about the prewar average. Winter killing will probably be severe, and the Hessian fly is a serious menace. The spring wheat to be seeded this season must be the main dependence.

But labor, with high prices for machines and tools, is working against a large food production of any kind. The lure of high wages is taking labor from the farms to the industrial centers. Those that remain demand automobile factory wages and union hours. The situation is so serious that the Department of Agriculture is even now advising the country of the danger of a small production of foodstuffs this year. The conditions that prevail here will also affect Canada—inefficient labor demanding more than the farmer can pay, which may result in letting much land lie fallow.

The International Institute of Rome reports winter crops in central Europe, northern Africa, and Japan generally good, but only average in Britain. The British Government is even now raising the subsidy on domestic wheat to encourage larger plantings in 1921. It is certain that Europe will call for the average amount of grain, meats, and fat, and the present outlook is not such as to encourage the belief that we can supply them and feed our own population.

Two courses lie open if a lack of food is to be averted. One is an increased production of spring-planted crops, which farmers now claim they can not produce at a profit. This can be done only by cheaper and more efficient labor. The other course is in the direction of Russia. Whether or not Russia's peace offers are for the purpose of propaganda, the hope of averting a food shortage lies in that direction. Implements, tools, and transportation are lacking, but with these supplied Russia can again take its place as an exporter of foods. Without it the prospect is not cheering.

The situation is indeed serious, gentlemen, when the Wall Street Journal becomes anxious over the difficulties of the farmer. It is a fact acknowledged by all students of agriculture that those engaged in that industry in the past have not received the cost of production plus a proper return on their investment, and in addition a reasonable net profit, and the result of the scarcity and high prices commanded by labor in the industry of the country is that the farmer can not compete for this labor and is forced, not through any desire of his, but by necessity, to limit his acreage production. The use of fertilizer is one of the great labor-saving devices of agriculture.

There are two matters of legislation pending before this present Congress which offer assistance along two different lines to the agricultural problems of the country, production and distribution. One of them is this pending legislation for the operation by the Government of the nitrate plants and the power being developed at Muscle Shoals in the interest of agriculture, an accomplishment which we earnestly believe will give us much needed assistance to meet the present production conditions that the farmer is forced to meet, the most difficult of which is labor. The other is, if I may be permitted to refer to it, the Capper-Hersman bill now pending before the Judiciary Committees of the Senate and House, which grants us the undisputed right to cooperatively market our products once they are produced. No other legislation is before this Congress or has been adopted by this Congress that attempts in any way to come to the relief of the serious agricultural situation in the country, and it is our earnest request that these two pieces of legislation be promptly enacted into law during the present session of Congress.

That the committee may not believe we have been carried away by the remarkable study and presentation of this subject prepared by the War Department and presented to this committee, I think a short history of the interests of the farmers' organizations in this very nitrate fixation question would at this time be most valuable.

The first resolution passed by the farmers' organizations on this subject, of which I have any knowledge, was the resolution, copy of which I wish to offer here, unanimously adopted by the National and State officials of the Farmers' Union and of the Grange in joint conference in Washington on February 8, 1916 [reading]:

Resolution adopted by the National and State officials of the Farmers' Educational and Cooperative Union of America and of the National Grange, in joint conference, with a unanimous vote, urging Congress to enact such legislation as will authorize the building of dams by the Government for the development of power for the fixation of nitrogen of the atmosphere as a fertilizer, and to provide nitrates for the manufacture of powder to supply the Government needs.

Whereas nitrogen is an indispensable element of plant food and on a great many of our soils is the limiting factor of crop production, and

Whereas this country is entirely dependent upon the country of Chile for its supply of nitrates, both as to quantity and price, which fact the Government of Chile has used to exact an export tax of between $11 and $12 per ton on nitrates which we pay, and

Whereas, the cost of Chilean nitrates before the European War was so high as to almost prohibit its use, and since the European War there is not even a supply of Chilean nitrates at any cost: Therefore, it is hereby

Resolved by the National and State Officials of the Farmers' Educational and Cooperative Union of America, and by National and State Officials of the National Grange, in joint conference:

(1) That we hereby, as strongly as possible, appeal to the President and Congress of the United States that during the present term of the Sixty-fourth Congress such legislation shall be enacted as will authorize the construction of a dam or dams for the development of the necessary power for the fixation of the nitrogen of the atmosphere as a fertilizer, and in such quantities to supply the needs of the Government and as far as possible supply the demands of agriculture, and by this development free, in part, the farmers of this country from the Chile saltpeter monopoly.

(2) That we ask, in order to prevent this great necessary industry from becoming a monopoly, that any dams built by the Government to create this industry shall forever remain in the ownership and control of the Government.

(3) We insist that the location of this air nitrate industry be determined with reference to the agricultural interests of his country and that a site be selected that has near it a source of limestone, coke, and phosphate rock, as has been recommended by the Department of Agriculture, and that furthermore, if possible, it be selected closest to the greatest consumption of fertilizer in this country.

(4) We recommend Government ownership and control in order that the cheapest money available may be used in the development of this industry and in order to regulate the prices of air fertilizers and protect the farmers

of the country against monopoly, and since nitric acid is an essential munition of war, and this Government is now dependent upon the country of Chile for its supply of nitrates for the manufacture of powder, any water power developed by the Government should be owned by the Government.

(5) That our legislative representatives are requested to present a copy of these resolutions to the President and to each Member of the Senate and House of Representatives of the United States.

Adopted unanimously, February 8, 1916, at Washington, D. C.

C. S. Barrett, president Farmers' Educational and Cooperative Union of America; Oliver Wilson, master National Grange, Patrons of Husbandry; A. C. Davis, national secretary Farmers' Educational and Cooperative Union of America; L. C. Crow (Washington); L. M. Rhodes (Tennessee); M. McAuliffe (Kansas); O. F. Dornblaser (Texas); George H. Bowles (Virginia), executive board Farmers' Union.

This has been followed by resolutions adopted by the National Grange November 14, 1916, by the National Farmers' Union on November 24, 1916, to which resolution I will refer again at a later place, and other resolutions which have been adopted continuously by National and State organizations of farmers from that time to the present date, and I believe it will serve my purpose to call your attention now to three of the latest resolutions that have been adopted, one from the Aroostook Federation of Farmers, in Maine; one in February by the National Board of Farm Organizations; and the other by the recent national convention of the American Farm Bureau Federation in Chicago on April 3. So that we have not jumped to any hasty conclusion and been seriously misled, as has possibly been indicated to your committee in the hearings preceding this.

(The resolutions submitted by Mr. Bower are here printed in full in the record, as follows:)

Resolution of the AMERICAN FARM BUREAU FEDERATION presented and adopted at its annual meeting held at the Hotel LaSalle, Chicago, March 4, 1920.

* * * * * * *

We support the measure pending in Congress looking toward the operation of the nitrate plant No. 2 at Muscle Shoals for the production of nitrogen fertilizer compounds.

NATIONAL BOARD OF FARM ORGANIZATIONS,
Washington, D. C., February 24, 1920.

The following resolution was adopted at the annual conference of the National Board of Farm Organizations held at the home of the board, 1731 I Street, Washington, D. C., February 19 and 20, 1920.

CHARLES A. LYMAN, *Secretary.*

FERTILIZER REPORT, NITRATE PLANTS AT MUSCLE SHOALS, ALA.

Whereas the war emergency needs for nitrogen compounds for explosives resplosives resulted in the building at Muscle Shoals, Ala., of an immense plant for extracting nitrogen compounds from the air; and

Whereas careful estimates of the War Department show that this plant can make an important contribution toward a larger and cheaper supply of nitrogen compounds for fertilizer; and

Whereas this plant is now idle and action of Congress is required before it can be operated, and whereas a bill has been introduced for this purpose; Therefore, be it

Resolved, That the National Board of Farm Organizations appoint a permanent fertilizer committee with power to call in such additional assistance as may be needed to support proper legislation providing for well-considered Government operation of the nitrate plants at Muscle Shoals and to look after such other fertilizer matters as may vitally affect the interests of American agriculture.

RESOLUTIONS PASSED AT MEETING OF BOARD OF DIRECTORS, AROOSTOOK FEDERATION OF FARMERS, DECEMBER 2, 1919, IN FAVOR OF THE MUSCLE SHOALS FERTILIZER PROPOSITION.

Whereas we understand that the War Department experts who developed the Muscle Shoals munitions plant of the United States Government on the Tennessee River in Alabama have, or soon will, ask Congress for the appropriation of a revolving fund for the purpose of converting that great plant into a fertilizer factory; and

Whereas we are informed that the Government will continue to own and manage said plant in order to maintain it in efficiency and instantly available for the manufacture of explosives in case of need; and

Whereas Aroostook County is desperately in need of cheaper fertilizer, which we believe the efficient management of the proposed plant will tend to secure for us: Therefore

Resolved, That we, the directors of the Arostook Federation of Farmers, in meeting assembled, respectfully urge our Senators and Representatives to make a careful investigation of the merits of the proposition to the end that if it shall appear that said plant will tend to make us even partially independent of Chilean nitrates they give to it their cordial support; and be it further

Resolved, That a copy of these resolutions be forwarded to each of our Senators and Representatives in Congress.

It is the duty and business of a farmer to raise as large crops from his soil as it is possible to obtain, but it is his sacred obligation in his partnership with all Government and with all society to maintain the fertility of his soil so that future generations shall not suffer. The time to guard the fertility of the soil is when it is still fertile, when the men owning and tilling it have or may secure the capital and have the intelligence and efficiency to properly conserve that soil because, I tell you gentlemen of the committee, that poor soil leads to poverty and unrest and results in inefficiency, with the consequent loss of education and intelligence.

The increased use of commercial fertilizers is becoming more and more a necessity in the agriculture of this country, and this fact is further emphasized by the knowledge that no longer can we increase our agricultural production by increasing our acreage in crops. Practically speaking, the commercially arable land of this country is under cultivation to-day. One of the criticisms of agriculture to-day is that it is inefficient in its cultivation, but the efficiency of cultivation is limited by the fertility of the land cultivated. It does not pay to efficiently cultivate poor land. An increased use of commercial fertilizer will undoubtedly increase the efficiency of cultivation on our poor lands. The time has come in this country when, if we do not take action now to maintain the fertility of the soils of America, we are neglecting our greatest duty to this country and this Government.

There is a fundamental fact, gentlemen of the committee, that we do not believe has been presented to you as it appears to us. There has been so much talk about production of ammonium sulphate, with a special emphasis on the production capacity, which we will explain later, that we seem to be surrounded with floods of nitrogen compounds. They seem to roll in from every source. But a farmer is not interested in increased production or increased quantities of nitrogen compounds or any other fertilizer compounds unless it is accompanied by a reduction in the price of these compounds. The price of commercial fertilizers, and of nitrogen compounds most especially, has prevented their application to any of the cereal crops of this country and limited it to those in which there is a large money return per acre. This committee will readily understand that in the consumption of an article such as fertilizers, where its application must return an economic profit to the farmer, that the price is necessarily the factor upon which consumption is based. As an illustration, an unlimited production of nitrogen compounds, such as ammonium sulphate, at a price of $200 a ton would in no way benefit the fertilizer consumer. Before the Agricultural Committee of the House, in February, 1916, Mr. Washburn made the following statement:

> Any man or any nation can very easily take credit for being independent as to the supply of anything the cost of which is prohibitive for its most important purpose and exces ive for all other uses, for the very good reason that under such conditions the demand as to quantity is extremely limited. (Hearings before the Committee on Agriculture of the House of Representatives, Feb. 9, 1916, p. 8.)

The estimated consumption of fertilizers as presented by the War Department does not take into account the fact that future production from now on must be increased almost entirely by increased yield per acre. In the future fertilizer application has not got to compete, as it has in the past, with crops produced from new soils just brought under cultivation. Regardless of taking this possible great increase of fertilizer consumption into account, the consumption of fertilizer is limited by its cost and, with a lowered cost to the farmer, I venture to say there is no one who will attempt to make more than a rough estimate as to what the consumption may be in this country. Consequently, in addressing ourselves to this problem we have continuously had in mind that the result which we are seeking most earnestly to obtain is not an increased production of fertilizers, but an increased production of cheaper fertilizers.

Nature has been most generous in supplying the elements of plant food. Of all the constituents that go to feed a plant, there are only three which, on arable soils, are ever inadequately provided by nature herself, and these three are nitrogen, phosphorus, and potash. These three elements make up only a portion of 5 per cent of the chemical elements secured from the soil and absolutely required for the growth of every agricultural plant, the other 95 per cent being made up of compounds of carbon, hydrogen, and oxygen obtained by the plant from the air and water. Of these three elements, the most important in the problem of maintaining the permanent fertility of the soil is nitrogen, and on the majority of soils it is the limited supply of this element that becomes the limiting factor in the production per acre. On most of our so-called worn-out eastern soils, the lack of nitrogen in these soils most seriously prevents their cultivation, phosphorus coming next, and potash, because of its usual presence in the soil in considerable quantities, is of the least importance.

A simple illustration of one of America's great cereal crops will demonstrate the importance of nitrogen.

A 100-bushel crop of corn, according to Dr. Cyril G. Hopkins, takes from the soil in grain and stalk a total of 148 pounds of nitrogen, 23 pounds of phosphorus, and 71 pounds of potassium. I might pause here just for a moment to say that Dr. Hopkins was the late agronomist in the University of Illinois and was considered one of the leading experts on soil fertility in the country, and who died at Gibraltar during the war while returning from agricultural work in Greece. And an illustration of this demand for nitrogen is given by Dr. Hopkins in his book on "Soil Fertility and Permanent Agriculture," in which he discusses the establishment of a plant producing 10,000 tons of calcium cyanamid per year, is the following:

> It should be noted, too, that the 4,000,000 pounds of combined nitrogen which such a plant could produce in one year would be sufficient, if none were lost in drainage waters, to meet the "growing demands" of the average corn crop of the United States for less than 200 minutes.

In 1909 the three great cereal crops of America, corn, wheat, and oats, removed from the soil in the grain alone 3,965,000,000 pounds of nitrogen, 606,000,000 pounds of phosphorus, and 875,000,000 pounds of potassium. Reducing this nitrogen to tons of ammonium sulphate shows that to replace this amount with ammonium sulphate would require 9,912,500 tons of ammonium sulphate. This is an indication of the demand for nitrogen in agriculture, and the satisfying of this demand is limited only by the cost of the materials. These facts demonstrate the overshadowing position which nitrogen compounds hold in the problem of maintaining and increasing the fertility of the soil. At this point I wish to quote from the hearings before the Committee on Agriculture of the House on February 9, 1916, where Mr. Washburn makes the following statement:

> I believe, therefore, that the best way in which I can contribute something of possible value to your deliberations is to confine myself in the main to what is possibly the most important single difficulty the farmers of this country face in the matter of fertilizing their crops, and the most effective single remedy therefor. I refer to the always high and frequently prohibitive cost of the nitrogen fertilizer as the difficulty, and to Government cooperation in the establishment of the nitrogen industry within the borders of the United States as the remedy.

It is our earnest belief, gentlemen of the committee, with these facts as to the fertility of the soil and the demands now being made upon it for the crops we are producing, that the activity of securing nitrogen compounds from the air for use in agriculture on a basis of the public good that will result from cheaper nitrogen compounds, is properly a governmental activity. Especially is this true when in this new industry of fixing nitrogen from the air the great water powers of the country are called upon to perform this service. The interest at stake is so great and the results to be obtained are so applicable not alone to the farmers of the country but to everyone who consumes food and wears clothing, that it seems to us no place for private industry to step in and propose to limit the supply and demand its profits.

You have had a very able and exhaustive study of this whole situation presented to you by the officials of the War Department, and one of the statements of Secretary Baker impresses us most focibly in this matter—I refer to his answer to Senator Smith of South Carolina, on page 13 of the hearing, where he states that this industry is in its period of infancy, and he goes on:

> From the agricultural point of view these processes are all now being developed by scientific research, and I think it is to the interest of the agricultural people of the United States to have the Government itself, which has no interest in the matter except their interest, has no commercial interest in continuing an

inefficient process or in advertising an inefficient process, but has every interest in developing the best process—the Government itself should continue the operation of these plants and proceed with a continuous system of scientific inquiry, with the idea of perfecting the product so that it will be the very best that can be gotten for agriculture and will be produced under the most favorable conditions. We think this attitude is most strikingly borne out by what has been testified before this committee as to what Germany has done in the past, is doing to-day, and is preparing to do in the future with regard to the nitrogen-fixation industry.

It is very evident from the following statement by Col. Joyes that Germany has recognized the importance of nitrogen and has made it a government activity. He says:

> This information, which comes from most reliable sources and is not to be disputed, shows that beyond question anyone outside of Germany producing or desiring to purchase nitrogenous fertilizers or similar compounds will have to deal with a single organization, essentially a branch of the German Government, which will have an absolute monopolistic control of all such products produced in Germany or whatever surplus there may be for export. (Hearing before Committee on Agriculture and Forestry, U. S. Senate, S. 3390, Mar. 22, 1920, p. 52.)

What they have accomplished is borne out by the following extract from Dr. Max Sering, senior professor of economics, University of Berlin, in a letter published in Current History in September of 1915:

> The complete cutting off of the supply of Chile saltpeter during the war has been made good by our now taking nitrogen directly out of the air in large factories built during and before the war. With extraordinary rapidity the question has been solved how the enormous quantities of the needed ammunition were to be produced, a question which in England still meets with difficulties in spite of the help from America. It is, however, not only for the needed explosives that we take nitrogen from the air, but also for the nitrogen-containing fertilizers which we formerly imported in the form of Chile saltpeter.

And also by this statement from Dr. Hugo Schweitzer, in an article in Review of Reviews, August, 1915:

> With this cheap power Germany has been able to produce new nitrogen compounds which threaten to revolutionize our present system of fertilization. This industry, to which the war has given the impetus, has assumed such dimensions and has given such unexpected results, that the Government requested the German parliament to grant an imperial nitrogen monopoly. From the official documents, it appears that chemical compounds have been discovered which allow the production of a universal fertilizer.

The committee will be interested to know that Dr. Hugo Schweitzer, upon investigation by the Department of Justice during the war, was proven to be Germany's master chemical spy in this country, and he mysteriously disappeared in the fall of 1917, and it is thought that he is either dead or is now in South America.

In testimony in 1916 before the Committee on Agriculture of the House on the agricultural appropriation bill, it was stated that "the answer to the fertilizer problem to be of any practical and immediate value must lie in revolutionizing present conditions instead of a slow evolution proceeding under their domination." And again this testimony at that time was made by Mr. Frank S. Washburn.

With such considerations as these, to characterize this great Government undertaking as socialism, as communism, and it has been so characterized before this committee, seems to us to be raising in opposition mere words that have no practical meaning in this connection whatever. I would like to read, if I may be permitted, an extract from the Washington Herald of March 29, 1920. [Reading:]

> A number of farmers' associations of the country have expressed themselves in favor of continuing the use of this nitrate plant to add to the supply of the fertilizer which it is capable of making. Objection is made to the Government's entering such business by the manufacturers of the by-product coke, which furnish a similar fertilizer.
>
> On general principles the Government should not enter into competition with private enterprise in such a purely commercial business; but the circumstances here are exceptional. The nitrate plant is a most important addition to the preparation of the Government for war and would make us independent of the nitrate beds on the west coast of South America. It would seem wise, therefore, to maintain the plant, and in so doing to save the cost of its maintenance by profit from a peace product that would not interfere with the use of the plant when the war exigency arises. It is said, too, that the demand for this form of fertilizer is so great that it is unlikely that the by-product coke producers will be seriously injured by the competition of the Government.

We have not the temerity to suggest that ex-President Taft is a socialist or a communist.

The CHAIRMAN. We do not consider ex-President Taft as an authority on agriculture, and I hardly think it worth while to take up too much time reading what he may have to say on that subject.

Mr. BOWER. While we do not consider him an expert on agriculture, and this is not presented with that idea in view, yet I thought it might be of interest.

The CHAIRMAN. We do not care to discuss that, but I do personally know that ex-President Taft knows absolutely nothing about agriculture, so what is the use of bringing in a statement here by a man who is not by any means informed on the subject. He is a judge and an able man in his line, but we do not want authorities of that kind in agriculture.

Mr. BOWER. We are not bringing in the statement of ex-President Taft as an authoritative one on agriculture, but think it might be of interest in this connection as a general proposition.

Would anyone argue at this time that the Government should return the postal system of the country to private interests; that the recent addition to the postal service of the parcel-post system should be returned to the private handling of these parcels by the express companies, and yet everyone remembers the opposition to the parcel-post system based on the same arguments that have been presented as reasonable against this development, that is, that it was putting the Government in business in competition with interests already in that business, and we farmers particularly remember the bitterness of that fight between the agricultural interests and the express companies of the country. It was argued that the establishment of the Federal farm-loan system was embarking the United States Government into commercial banking channels entirely outside the jurisdiction of the United States Government and in competition with private banking interests, and yet the recognized fact that agriculture must have cheaper interest rates on its money, connected with the knowledge that private interests were unable or unwilling to give this cheaper rate, enacted the Federal farm-loan system, and no one to-day will question its necessity. It has been referred to as the Magna Charta of American agriculture.

And yet if we are intelligently to attack this problem of maintaining soil fertility, a cheaper source of the elements of plant food is more necessary even than cheaper money to the farmer. To avoid this stigma of socialism and communism, must we sell the Panama Canal to private interests and until this sale can be effected close it up? To prevent the exploitation by a monopoly of the resources of Alaska, the Government itself built the Alaskan Railway. Shall we not prevent by this legislation the exploitation of the American farmer in his nitrogen requirements by private monopoly? The sale of the ships of our merchant marine was prevented by an injunction, and I suggest most seriously that the farmers would feel as deeply aggrieved if this great Government plant was turned over to private interests after having been built and paid for with the people's money. The United States Government has spent hundreds of millions of dollars in the improvement of river navigation, and where this has been done it has resulted in competition with the railroad business of the country, and has acted as a regulation of their rates. Shall we not, through this plant, regulate prices of nitrogen fertilizer materials?

And to set up a parallel case in the activity and in the results that are obtained is there any member of the Senate to-day who says the Government should abandon its irrigation projects of the West, upon which it has expended over $154,000,000, and turn them over to private interests? And yet let us examine this case for a moment. On the western arid lands the requisite for crop production is water, and the United States Government builds dams, constructs canals, and puts water upon that western land for the production of crops. The requisite for crop production on our eastern and southern, as well as and increasingly so on our western soils, eventually on this same irrigated land, is the application of so-called commercial fertilizers. The activity of the Government at Muscle Shoals is to build a great dam, run the water through turbine wheels, generating electric power that will produce fertilizers that can be applied to the soil for the purpose of increasing crop production. If one is socialism and communism, the other must undoubtedly be placed in the same class.

We believe Mr. Washburn in his recent testimony has placed this plant by his own definition among operations that are fundamentally governmental: "The Government officials are in a position that does not involve those things that are properly governmental care, broadly, the political matters and the guarding of our liberties and the doing of those things that are so exclusively public of their nature that they can not be done profitably and satisfactorily by private industries"—"Yes," he says, "that is the field and that is where, in connection with that sort of activity, we should train our public officials." It is impossible for us to conceive of anything more public in its nature and more beneficial to the public welfare than the development of our great water powers, the heritage of the people, for the purpose of the manufacture of fertilizers to increase the productivity of our soil, and in 1916, testifying before this committee, Mr. Washburn stated:

"I have never personally thought it was feasible for private capital to develop or assist in the development of power at Muscle Shoals and then sell that power to a nitrogen industry." (Hearings before

Committee on Agriculture and Forestry, U. S. Senate, S. 4971, p. 48.) Again, in the recent hearing, Mr. Washburn stated: "The development of the Muscle Shoals situation always did mean cooperation between private capital and the Government." Frank admissions, gentlemen, that private capital was unable, because of the immense amount of capital required and the rates of interest they would have to pay to adequately establish the nitrogen fixation industry in this country.

With this consideration of the fundamental facts in connection with the place nitrogen holds in the problem of soil fertility, it is demonstrated that from the standpoint of the public welfare the operation of this plant is a proper governmental activity and is worthy of the greatest endeavors and the most intelligent effort that the Government can apply to this problem. To trust the air nitrogen production of this country to private interests which are not even established in the country is to jeopardize our national security from the standpoint of agriculture just as seriously as from a standpoint of military preparedness.

The next question that presents itself is: Can the Government, through the operation of this plant, secure the desired results? As a broad principle it is an acknowledged fact that regardless of cost the future supply of nitrogen compounds must come from fixation of nitrogen from the air. The second fact that is recognized by all authorities of air nitrogen fixation is that in the form of cyanamid nitrogen can be fixed from the atmosphere and takes its place in the markets of the world as the cheapest form of combined nitrogen available from any source not excepting ammonium sulphate, Chilean nitrate, or any organic waste compounds. To the farmers this is the great outstanding fact in this whole situation. Passing over for the moment the difficulties in the use of cyanamid as a fertilizer, and we recognize that these difficulties exist, how much cheaper is cyanamid than these other nitrogen compounds?

The estimated cost submitted by the Ordnance Department shows that the waterpower cost of producing cyanamid is $24.57 per ton, plus the royalties of 52 cents to the Air Reduction Co., and $5.75 to the American Cyanamid Co., makes a cost of $30.84 a ton, or $1.54 per unit of ammonia. We wish to call your attention to the fact that in this price we have figured the royalties as provided in the contract to be paid to the American Cyanamid Co., because we grant without argument the contention that the United States Government will live up to any contract that it has signed and is in force, and we have not considered, which, however, we deem possible, that in the arbitration of these royalties provided for in the contract, it may be found that they are somewhat too high.

The CHAIRMAN. Mr. Bower, I do not want to interrupt you, but will you in your argument discuss the question touched upon by Mr. Marsh as to the necessity of the Government having at least some supervision over phosphate and potash?

Mr. BOWER. I will come to that, but from a somewhat different angle.

The CHAIRMAN. All right; you may continue your statement.

In 1916, before the Agricultural Committee of the House, Mr. Washburn testified that his cost of producing a unit of ammonia at the American Cyanamid Co. plant in the form of cyanamid was as follows (p. 16 of the hearing):

> The **Chairman**. What is it costing that plant to turn out nitrogen fertilizer per ton?
>
> Mr. **Washburn**. Per unit of ammonia?
>
> The **Chairman**. Yes.
>
> Mr. **Washburn**. The direct cost, leaving out selling and overhead charges and items of that kind, which all vary with the quantity, is about $1.25 per unit of ammonia.

And again, in testifying before this same committee of the Senate in 1916 Mr. Washburn says (p. 5):

> What has been obtained, economically speaking, is this: That the factory cost, under most favorable conditions, those which are not only theoretically obtainable, but actually obtainable in some parts of the world, everything, including overhead and superintendence and all that sort of thing inside the factory, but not including interest on the investment, for producing nitrogen, comparable to the nitrogen that is in the Chilean nitrate, is about one-third of the ordinary market price of the Chilean nitrate.
>
> Senator **Smith**. You mean to say that the factory cost is about a third of the selling cost?
>
> Mr. **Washburn**. Of the selling cost of Chilean nitrate.
>
> The **Chairman**. Suppose you put that in figures, giving the price in ordinary times.
>
> Mr. **Washburn**. I am talking of Chilean nitrate at the rather low figure of $2.40 to $2.60 per unit of ammonia, which is the unit that is employed universally in agriculture, equal to 20 pounds of ammonia; and the cost in a well-placed, well-conducted cyanamid factory is 80 to 90 cents a unit.
>
> Senator **Smith**. Expressed in tons, it would be about $50 a ton for the Chilean nitrate?
>
> Mr. **Washburn**. About $50 a ton, and for a ton of cyanamid material having the same amount of nitrogen it would be about one-third of $50, or, say, $17.
>
> That is the result, one might say, broadly speaking, of 16 years of development.

So that it is evident that the cost submitted by the Ordnance Department, even including the royalties that Mr. Washburn contends for, is demonstrated as a conservative cost when compared with Mr. Washburn's own costs at Niagara Falls. What this means in the cost of nitrogen fertilizer compounds is very evident at once when this cost is compared with the selling price fixed by the ammonium sulphate manufacturers for their product, which is $3.60 per unit of ammonia for the coming year; that is, the cost of cyanamid is less than one-half the selling price of ammonium sulphate. In 1916 Mr. Washburn contended before the Agricultural Committee of the House and the Military Committee of the House and before this committee of the Senate that the air-nitrogen industry established in this country at Muscle Shoals would reduce the price of the fertilizer for the American farmer by 50 per cent, and I quote from these hearings:

> Mr. **Heflin**. What reduction in the cost of fertilizer to the farmer do you estimate could be expected if the Government were to carry out your suggestions for the construction of dams for taking nitrogen from the air?
>
> Mr. **Washburn**. My anticipation is that the establishment of the nitrogen industry, as it can be established with what I believe and what I believe would appeal to those who study the subject is the proper and legitimate Government cooperation, will give the farmer his fertilizer for one-half of what he would otherwise pay for it. (Hearings before Committee on Agriculture of the House, February, 1916, p. 13.)

Dr. L. H. Baekeland, testifying before this committee of the Senate in 1916, made practically the same statement in these words:

> The statement is made by the present Government monopoly in Germany that after the war is over and after what they know now about the synthetic manufacture of nitrogenous fertilizer from the air, after all the experience they have acquired during this war while making nitric acid, that they will be in such condition that they intend to furnish to the farmers of Germany nitrogen fertilizer at about one-half the price it is costing the consumer here in the United States. If Germany can do that, gentlemen, there is not the slightest doubt in my mind that we can do the same here or that we can do better. (Hearings before Committee on Agriculture and Forestry U. S. Senate, S. 4971, p. 113.)

Now, when we consider this testimony submitted in 1916 in the light of the estimates prepared by Dr. Glasgow and submitted by the War Department after nearly a year's study as to what they might do with these great nitrate plants, and it must unquestionably be realized, gentlemen, that there was no collaboration between Dr. Glasgow and Mr. Washburn in arriving at these figures, it appears to us that this most valuable saving of one-half in our nitrogen fertilizer compounds is ready to be accomplished.

A most remarkable thing to us, and which we admit we can not understand, is the wonderful ability and efficiency of this plant in making nitrogen compounds for explosives, and yet its striking inefficiency and disability for making nitrogen compounds for fertilizer. Mr. Washburn, before this committee recently describing the manufacturing operations of nitrate plant No. 2, said:

> The capacity of the plant, the economy in power consumption, the low cost and purity of the product, all surpass expectation. That was a 100 per cent result in every particular. Had the Muscle Shoals plant been operating for the three years contemplated in the agreement, based on the proven cost during the period of its actual operation, the Government would have saved a sum in comparison with the cost of the product from other sources equal to the entire cost of the plant and twenty million dollars in addition thereto.

If this plant is able, as Mr. Washburn testifies, to charge off its entire cost of construction and make an interest return to the Government of $20,000,000 in three years in the manufacture of nitrogen compounds for explosives, it must be very evident to the committee that our contention is a reasonable one that a result of a similar kind can be expected when this plant is operated for the manufacture of nitrogen compounds for fertilizers.

We fully appreciate the difficulties that have been presented to this committee as to the use of cyanamid, but we most certainly can not grant the assumed implication that these difficulties can not be overcome, and it is this very thought that impels us again most strongly to seek the protection of Government operation of this plan in that this difficulty being overcome, the public good demands that this cheaper nitrogen compound be made immediately available to the American farmer in his efforts to increase production with the least possible drain upon the soil. It is, in our opinion, absurd to assume this difficulty being overcome by private industry engaged in the fixation of atmospheric nitrogen when this industry is lined up as has been made evident to this committee, with the great fertilizer interests of the country, that these results will be passed on to the American farmer.

As an illustration, I think it has been demonstrated that the cost of producing cyanamid at Niagara Falls can be conservatively placed at about $30 a ton, and yet Mr. Washburn has testified to this committee that his selling price for cyanamid is $87.50 to $100 a ton, and he has further testified that the market for cyanamid is saturated with 36,000 tons of cyanamid.

Senator RANSDELL. Did I understand you to say that from some past investigations that you have made you know that cyanamid can be produced at $30 a ton, or that Mr. Washburn says that?

Mr. BOWER. Mr. Washburn submitted a price of $1.25 per unit of ammonia. That would figure out about $24 a ton.

Senator RANSDELL. That was some time ago?

Mr. BOWER. Yes, sir. And I have added $10 a ton additional, and yet I know he is operating under the same power contracts and with the same power prices, which is one of the main costs he had then.

Senator RANSDELL. And you think it could not cost over $30 a ton?

Mr. BOWER. Yes, sir. I would say that $30 a ton is a conservative cost estimate as of to-day.

Senator RANSDELL. Yes; but that is $4 less than $10 added. That is only adding $6 a ton to the old cost instead of $10, as you say.

Mr. BOWER. Yes, sir; it is only adding $6 per ton, for increase in labor. Power, which is the particular thing, is not costing him any more because he is operating under the same power contracts.

This may presumably be true at that price for cyanamid of $87.50 to $100 a ton, but I deny the implication that that market would be saturated with 36,000 tons of cyanamid, say at $37.50 a ton, because, in all the testimony as to the consumption of nitrogen compounds for fertilizer the fact that cost to the farmer is the deciding factor in the amount consumed has been entirely neglected.

You have heard Mr. Washburn's arguments for the protection of the ammonium sulphate industry, and that very argument is an indication to us of what we will have to pay for nitrogen compounds, regardless of how cheaply they may be produced if this industry is developed by private enterprise.

But for the moment admitting the temporary disability of the American farmer to use the entire output of this plant in the form of cyanamid, the tiding-over solution presented by the War Department appeals most forcibly to us. Disregarding all this quibbling before the committee as to nitrate nitrogen and ammonia nitrogen for the moment, ammonium sulphate is an established and well-recognized and a most valuable nitrogen fertilizer compound. It is exactly as Mr. Roberts stated to the committee. It is a product upon which they can place entire confidence for operating this plant, entirely suitable for the present usage in American fertilizer consumption.

The report of the Federal Trade Commission on the fertilizer industry, published in August, 1916, gives on page 173 a table showing the principal high-grade fertilizer materials used in mixed goods by the seven largest companies during the season of 1913, which table shows that these companies in preparing the mixed fertilizer that at present goes to the American farmer used 55,153 tons of nitrate of soda and 75,410 tons of sulphate of ammonia.

The explanation of this increased use of sulphate ammonia is at once recognized if you will turn to plate 17, opposite page 91, in the hearings of the War Department presented to this committee showing the relative cost per unit of nitrogen in sulphate of ammonia and nitrate of soda. In 1913 sulphate of ammonia furnished a cheaper unit of nitrogen than did nitrate of soda. I think a most casual study of this plate will refute the entire argument as to inability of ammonia nitrogen to take the place of nitrate nitrogen. The close association of the prices of these two compounds over this period of years is a clear indication of their intense rivalry in the fertilizer market.

These are commercial facts as to the relative prices of nitrogen in these two compounds and are not highly technical scientific statements as to the disabilities of one as compared with the other. It is a commercial truth that these two materials compete with one another in the fertilizer market on the basis of price of nitrogen content. On this point I would like to quote a few experts in fertilizers that evidently disagree with Mr. Washburn, and for this purpose I quote the following extract from Dr. J. W. Turrentine, scientist in Soil Laboratory investigation, United States Department of Agriculture:

> Ammonium sulphate as a stimulator of plant growth compares favorably with sodium nitrate. While it is generally believed that the nitrate of soda is more immediately available for plant assimilation than the sulphate of ammonia, the two give practically the same results as fertilizers. The sulphate possesses a slight advantage in being a somewhat more nitrogenous body than the nitrate, containing 20 per cent nitrogen against the 15 per cent contained by the nitrate. (Nitrogenous Fertilizers Obtainable in the U. S., Bull. 37, U. S. Dept. Agriculture.)

Mr. Atwater, who is manager of the agricultural department of the Barrett Co., which company, by Mr. Atwater's own statement, handles 75 per cent of the ammonium sulphate sold in America, states, in answer to questions by Mr. Jefferis:

> Mr. JEFFERIS. Well, then, the two—that is, the Chilean nitrates and the ammonium sulphate—in effect are utilized for the same purpose in plant production?
>
> Mr. ATWATER. Yes.
>
> Mr. JEFFERIS. And if this country could produce all the ammonium sulphate that was needed for fertilizer purposes, of course, we would have no need for Chilean nitrates?
>
> Mr. ATWATER. We could get along without them. I can give you a case in point on that if it is germane to your question.
>
> Mr. JEFFERIS. Go ahead.
>
> Mr. ATWATER. England formerly used considerable nitrate of soda, and they only used 90,000 tons of sulphate of ammonia per year for all purposes in Great Britain itself. During the war they were hampered in Europe and were forced to rely on their own resources. They have now raised their home consumption of sulphate of ammonia to 270,000 tons per year in Great Britain. I have not the figures on the imports of nitrate of soda, but they are very much diminished, if not entirely eliminated. (Hearings before Committee on War Expenditures, Subcommittee 5 (Ordnance), House of Representatives, p. 8455, serial 6, pt. 53.)

Mr. Myers, who is a director of the work of the Chilean nitrate committee in the United States, and who is their chief propagandist for the use of Chilean nitrate in fertilizer, makes no such claim as to the superqualities of Chilean nitrate as compared with ammonium sulphate and ammonia nitrogens. In testifying before Mr. Graham's committee of the House in investigating war expenditures, Mr. Myers, in answering questions asked by Congressman Almon, says (p. 3552, par. 54):

> Mr. ALMON. But the selling price of sulphate of ammonia in the United States has nothing to do with the price of sodium nitrate, has it?

> Mr. MYERS. I should think not at the present time.
>
> Mr. ALMON. Well, if it ever had any, explain how it had an effect upon the price of sodium nitrate.
>
> Mr. MYERS. As one competing with the other is all I suppose; each of them furnishing form of nitrogen for agricultural purposes.

But for the moment let us return to Mr. Washburn's testimony of 1916. This proposed nitrogen industry, as advocated by him at that time, would reduce the price of fertilizers to the American farmer one-half and would compete with Chilean nitrate. On this very point, when testifying before this same committee of the Senate, on March 16, 1916, he was questioned by Senator Smith of South Carolina as follows:

> Senator SMITH. What I want to know is, can we get a substitute for the Chilean nitrate produced in this country? Is it practicable; is it feasible commercially?
>
> Mr. WASHBURN. Yes; along these lines. In order to have the mind upon something, let us take the situation at Muscle Shoals, on the Tennessee River, as an available power site, etc. (Hearings before the Committee on Agriculture and Forestry, U. S. Senate, March 1, 1916, S. 4971, p. 71.)

It may be contended by Mr. Washburn in rebuttal of this question that he was not figuring on the Muscle Shoals plant producing either cyanamid or ammonium sulphate, but producing ammonium phosphate. The complete contradiction of the two positions, the one in 1916 and the one to-day, is at once evident when you consider the form of the nitrogen in ammonium phosphate, which is a phosphate of ammonia. I submit, gentlemen, that the nitrogen in ammonium phosphate is not a nitrate nitrogen, but is an ammonia nitrogen which in 1916, according to Mr. Washburn's own statements, could replace the use of Chilean nitrate, but which, most difficult to understand, in 1920 would stimulate and increase the consumption of Chilean nitrate. And now he states before this committee:

> "The Muscle Shoals plant * * * can not produce any Chilean nitrate or any nitrate that will take the place of Chilean nitrate."

With these facts recognized, the whole contention of Mr. Washburn that the production from Muscle Shoals will only affect the material, which is 10 per cent only of the value of materials entering into commercial fertilizer, falls into the discard. Our contention is borne out by this evidence that production of cheaper ammonium sulphate at the Muscle Shoals nitrate plants will correspondingly regulate the prices of all inorganic nitrogen compounds entering into the manufacture of fertilizer, which, according to the table opposite page 74 of the hearings presented by the War Department, supplies 60 per cent of the ammonia entering into the mixed-fertilizer goods and must in future years supply an ever increasing proportion, as the organic nitrogen compounds, as has been demonstrated before this committee, are passing from the fertilizer market and becoming a valuable feed for live stock. In fact, already have high-grade tankage and cottonseed meal economicaly left the fertilizer market, and where these two materials are used to-day as a source of nitrogen fertilizer it is at a price fixed by their value as feedstuffs. In addition to this it is evident from the commercial viewpoint that, were the price of inorganics lowered, the gap between the two will widen, resulting in the increased usage of the inorganics, because the farmer will be unwilling for commercial reasons to continue the practice of putting these high-value feedstuffs into the ground as fertilizers.

Testifying before this committee in 1916, Mr. Washburn states:

> Our fertilizer bill in this country is about $175,000,000 a year, of which $75,000,000 is in nitrogen, or ammonia as we call it—the two terms are practically interchangeable—$65,000,000 in phosphoric acid, and $35,000,000 in potash. You see, potash is 20 per cent—75, 65, and 35. (Hearings before Committee on Agriculture and Forestry, S. 4971, p. 18.)

From this statement it is very evident the important place that nitrogen holds in the minds of the farmers of the country who consume fertilizers in that they pay more for nitrogen than either phosphorus or potash and get less nitrogen for their money, for 80 per cent of the mixed fertilizers sold to the American farmer was at that time prepared on a basis of 2 per cent ammonia, 8 per cent phosphoric acid, and 2 per cent potash. And it is our contention, and we believe it is borne out by commercial facts, that the production of the cheap nitrogen compounds at Muscle Shoals will reduce correspondingly the cost of all nitrogen compounds going into the manufacture of fertilizer, and this is exactly what Mr. Washburn meant in 1916 when he said that it would reduce the price of fertilizer to the American farmer 50 per cent.

Looking at this speculative difference in the values of nitrate nitrogen and ammonia nitrogen in the fertilizer industry from the standpoint of preserving soil fertility, I submit, gentlemen, that a form of nitrogen which is more slowly available and feeds the plant more continuously through its entire growing period is much more efficient and fills a much wider need than a stimulating nitrate nitrogen. Let me quote what Dr. Hopkins says on this matter in his book before referred to. On page 518 he states—

> the practice of the American farmer with respect to the use of commercial fertilizers has been essentially the continuation of his previous system of soil depletion, the fertilizer being used almost invariably as a soil and crop stimulant, which leaves the soil poorer and poorer with continued use.

The undoubted effect, gentlemen, of placing upon the market an ammonia nitrogen at an appreciably reduced price will be its substitution for Chilean nitrate, thus accomplishing a double purpose, of increasing the consumption of nitrogen fertilizer and at the same time supplanting a stimulant form with a form which more consistently furnishes the plant with its requirements during its period of growth.

When we discuss aside from the nitrate of soda used in mixed fertilizer the nitrate of soda applied as a top dressing and crop stimulant alone, in which case it is applied in most cases by hand, and especially is this true of its usage in truck and market gardening, ammonium nitrate, a nitrate nitrogen also made at Muscle Shoals, will undoubtedly take the place of Chilean nitrate for such uses with correspondingly increased benefits. For, in addition to the advantage gained by the lower price of ammonium nitrate and the price per unit of ammonia in ammonium nitrate, including full royalty to the American Cyanamid Co., is $1.88 a unit as compared with $4 a unit for ammonia at the present price of Chilean nitrates, $80 a ton, in addition to this advantage, there is a great saving to the user of that material in the freight which he pays in securing it from the factory, because his freight bill is cut exactly one-half, ammonium nitrate containing 35 per cent of nitrogen as compared with 15 per cent or

16 per cent nitrogen in Chilean nitrates. On this very point Dr. Hopkins, on page 528 of the volume quoted above, states:

> For long-distance shipping the final product from the artificial fixation of atmospheric nitrogen is, in the opinion of the author, to be ammonium nitrate.

And when I visited Dr. Hopkins and discussed this very question in 1917, at Champaign, Ill., he stated to me that in his opinion the most valuable product from such a plant as this one now built would be ammonium nitrate.

As an argument against the manufacture of ammonium sulphate at Muscle Shoals, Mr. Washburn testified before this committee that he was forced to abandon the manufacture of ammonium sulphate by the competition of the coke oven interests. I think that the reason for the abandonment of the manufacture of ammonium sulphate by Mr. Washburn is immediately evident when we consider the price he was able to secure for cyanamid itself, namely $87.50 to $100 per ton. Since he could secure this price for cyanamid there could be no possible advantage to him in carrying his manufacturing steps through to the production of ammonium sulphate for which at the present time he would be securing only $90 a ton, under these long-term contracts, because it must be evident that there is an additional cost of at least $20, which is slightly less than what the War Department estimates as a difference in their cost between cyanamid and ammonium sulphate, and with the prices that Mr. Washburn secured for cyanamid, this additional cost would represent a complete loss.

Mr. Washburn stated flatly before this committee that nothing would replace organic ammoniates. He said:

> I referred yesterday to the use of organic ammoniates, of which we use a great many in this country. They in turn can not be displaced. (Hearings before Senate Committee on Agriculture, April 9, 1920.)

I think this needs no further reply than a reference to this advertisement of cyanamid appearing in the Oil, Paint, and Drug Reporter of March 29, 1920, and also this copy of a statement to the trade. It looks as though some cunning gentleman was misleading the farmers a second time.

I wish to refer at this moment to an advertisement for cyanamid appearing in Oil, Paint, and Drug Reporter of the issue April 26, 1920, signed by the American Cyanamid Co., 511 Fifth Avenue, New York [reading]:

> Cyanamid is being used in the manufacture of ammo-phos, cyanide, aqua ammonia, and other cyanamid products.
>
> At the same time the demand for use as a fertilizer is greater than ever before. This demand is undoubtedly based upon: (1) Increasing recognition of the fact that cyanamid organic nitrogen replaces other organics at a large saving in cost.

Mr. Washburn told this committee that nothing could replace it, and yet his company is advertising that it does. It seems that some cunning gentleman is trying to mislead the farmer on the other side of the question now.

Mr. E. J. PRANKE. Mr. Chairman, I wrote that particular advertisement, and if you care to have me do so I would like to explain it.

The CHAIRMAN. Give your name and official connection.

Mr. **Pranke.** I am with the American Cyanamid Co. of New York. That statement means that cyanamid can replace organic nitrogen to the extent to which all the fertilizer men know cyanamid can be used, namely, 60 pounds of cyanamid in a ton of mixed fertilizer.

Mr. **Bower.** Oh, I grant that; but that does not change the status of cyanamid fertilizer replacing organics. There is that other limitation, and an entirely different one, Mr. Chairman and gentlemen of the committee, as to its deleterious effects when mixed with acid phosphate, which is the main objection to it. But that does not explain the fact that they advertise it is replacing organics which they have said nothing could replace.

As final refutation of Mr. Washburn's contention, both that the production of ammonium sulphate at this plant will not affect the price and also that ammonium sulphate can not compete with Chilean nitrate, I wish to refer this committee to the testimony given before the House Committee on Expenditures in the War Department, serial 6, part 53, in which Mr. Atwater, who is the agricultural manager of the Barrett Co., which company sells practically all of the ammonium sulphate sold in America, a commercial man certainly as familiar with the commercial marketing of nitrogen compounds as Mr. Washburn, when questioned by Congressman Almon, made the following most significant answers:

> Mr. **Almon.** If the ammonia sulphate could be made by the Government in the operation of its plant at, say, $43.81 per ton, what effect would it have upon the price of ammonia sulphate in this country?
>
> Mr. **Atwater.** I think all the sulphate will be sold at about that price.
>
> Mr. **Almon.** If ammonia sulphate could be made by the Government at its plant at, say, $43.81 per ton, what effect would it have upon the price of sodium nitrate, in your opinion?
>
> Mr. **Atwater.** I do not know whether the producers would come down to that figure. It would be about $30 for sodium nitrate—whether they would withdraw from the market, I mean. (P. 3474.)

With this situation, and when the best-informed man in the by-product coke industry as to the market conditions dealing with agriculture states that the production of this plant will lower the price of his product and possibly supplant entirely Chilean nitrate in fertilizer production, it is utterly ridiculous to assume that the benefit to the farmer will be $1 in $100, as stated by Mr. Washburn, because the entire nitrogen compound market for fertilizers is reduced to the level of the price of the product manufactured by the Government nitrate plant, which is exactly what we farmers have contended since 1916 would be the result of the building and operation of this plant, and will bring about a regulation of the entire nitrogen fertilizer market, and with it a complete change in the character of the fertilizers used by the American farmer with corresponding benefits to every citizen in this country.

Gentlemen of the committee, this is the crux of this entire situation. If this plant is operated and produces ammonium sulphate, then private interests at present engaged in furnishing these materials to the fertilizer manufacturers and to the farmers will be affected. Nothing else could explain the presence of Mr. Washburn before this committee and the testimony of Mr. Myers and Mr. Atwater before the Committee on War Expenditures, and to my knowledge there are other representatives of the fertilizer interests in Washington suggesting various solutions to this problem other than the operation of these plants by the Government.

This brings us, gentlemen of the committee, to the third phase of the situation, which is: What is the character of the private interests that are affected by this production at Muscle Shoals? The first statement I wish to make is an emphatic denial that there is any industry within the borders of the United States of America primarily engaged in the manufacture of nitrogen compounds for fertilizer usage. I do not think this fact can be stressed strongly enough in considering this problem, because you have had the plea of the private interests presented most strongly to this committee, and it has been most artfully represented to this committee that there are great private interests in this country that will suffer a tremendous loss if this plant is operated and produces cheaper nitrogen compounds, and in all probability that these great interests will have to cease their operations. This is entirely beyond the realm of facts as they exist. The sources of nitrogen compounds produced within the United States of America are without exception by-products of various industries which depend upon primary products for their support and commercial existence.

Let us take these affected industries one by one and analyze the effect it might have. Ammonium sulphate is a by-product of the coking of coal and its cost has been testified by Mr. Atwater before the Graham investigation committee (serial 6, part 53, p. 3441) as "a matter of bookkeeping, and one man would divide it one way and another man another way." Mr. Washburn testified before this committee that it cost $25 a ton to transform the ammonia into ammonium sulphate for the fertilizer market.

In the discussion before this committee the members have asked several times for an estimate of the cost of producing ammonium sulphate, and it is clear to me that the ordnance officers overlooked the fact that Mr. Glasgow, who is a man experienced in gas production and in the production of ammonium sulphate, has made an estimate on this very point in his report to the War Department. I think if the committee will consider the estimate of the cost of ammonium sulphate as given by Mr. Glasgow and compare it with the estimate of the cost of producing cyanamid at this plant, they will realize that the difference between these two costs represents the cost of producing ammonium sulphate. However, in this case, the cost of producing the ammonia from cyanamid is included, which cost the by-product coke-oven industry does not have to stand, as they secure their ammonia as a waste gas.

This difference under the different conditions as given in these various estimates is in all cases slightly over $20 a ton, and in the highest $22.11 a ton. The plant provided for in this legislation will be a modern one for treating ammonia gas with sulphuric acid, and the estimate is based on the cost of producing ammonium sulphate from ammonia gas. So that you have in fact an estimate made by an experienced engineer in gas works production on the cost of producing ammonium sulphate and this checks quite closely with Mr. Washburn's figures, given above, of $25. When we realize that this is the entire cost in the by-product coke oven industry of producing ammonium sulphate for sale as a fertilizer compound or allowing the ammonia gas to escape as a waste product, you see at once that we have to make some considerable improvements in our Muscle Shoals plant before we seriously cripple the by-product coke oven industry and force the United States Steel Corporation to increase its price of steel and iron.

It is well to realize at this point, gentlemen, that it is the United States Steel Corporation that is the largest owner and operator of by-product coke ovens, and Mr. Washburn is arguing for further protection of this gigantic combination which has had so many favors from the United States Government in the past. It is absurd to assume that any saving the steel corporation makes in the sale of ammonium sulphate from the by-product coke ovens is reflected in a lower price of iron and steel, but it must be very evident, gentlemen, that it is pocketed as an additional profit to this corporation.

At this cost of $25 a ton they have still considerable leeway to stay in the business and profitably manufacture ammonium sulphate.

Mr. Washburn has stated to this committee that the producing capacity of by-product coke ovens for sulphate of ammonia is 625,000 tons. According to the United States Geological Survey report the production of sulphate of ammonia in 1918 was 218,194 tons recovered from a by-product oven production of 25,997,580 tons of coke or an average of 16.8 pounds of ammonium sulphate per ton of coke made. The capacity of the ovens was 33,700,000 tons.

In 1919 the production of sulphate at the same rate per ton of coke made was 211,300 tons of sulphate, the coke production being 25,171,000 tons, the oven capacity being 39,500,000 tons.

In 1918, therefore, the ovens were being operated at about 79 per cent of capacity and in 1919 they were operated at about 64 per cent of capacity. In 1920 it is likely that they will be operated at about 50 per cent of capacity.

Simply because the chief product of by-product coke ovens is metallurgical coke. The consumption of coke in the United States, being dependent on the demands of the iron and steel industry, increased 22,000,000 tons between 1914 and 1918, an increase of more than 65 per cent. This enormous increase was due, of course, to the war, and until we have such a tremendous demand for iron and steel again in this country we will have no such production of coke, and until we have a production of coke to meet such an abnormal demand for iron and steel we will have no such production of ammonium sulphate.

But these statistics representing ammonium sulphate production do not state the facts. They represent the entire output of ammonia in all forms that is obtainable from by-product ovens when in full operation, and all of this ammonia is expressed in terms of ammonium sulphate. Not all of this ammonia is made available for the fertilizer market by any means. Forty-five per cent of this so-called ammonium sulphate is simply a production of ammonia in gaseous form that is absorbed in water and sold as aqua ammonia in refrigeration and other industries to meet their needs. What is left after these industries have been provided for is converted into sulphate and sold as a fertilizer ingredient. As Mr. Washburn stated in this committee, we get about 55 per cent of the total ammonia production in this form, and the balance is used in refrigeration and chemical industries.

The other sources of nitrogen compounds are also by-products. Cottonseed meal is produced from the crushing of cotton seed for the production primarily of cottonseed oil, and in this case these interests have already found a demand for the cottonseed meal that is largely supplanting its use in fertilizer and will within a few years absorb the entire production. Other sources are tankage and blood meal, by-products of the great packing industries of the country, and in the case of high-grade tankage and blood meal the increasing knowledge as to their great value as protein feeds in raising hogs is rapidly taking these materials from the fertilizer market, as has been demonstrated. These are the private interests within the borders of the United States that are affected by the operation of this plant.

The overshadowing interest, which is an absolute monopoly and which has heretofore dictated prices of inorganic compounds over the world is the Chilean nitrate monopoly, and in this connection we use the word monopoly with the full understanding of what that term means. Not only is it such a monopoly that the Chilean Government has continuously since 1880 exacted an export duty upon all shipments leaving Chile of $12.53 per long ton, which duty has not been changed since that time. In 1918 the export duty alone paid to Chile for the imports of nitrate of soda into this country from Chile amounted to $20,135,960.60. That was the payment from the United States to the Chilean Government for the privilege of buying sodium nitrate to make powder with. I have gotten up a complete statement of that, Mr. Chairman. I do not suppose you want to have that printed in the record, but there is the complete statement of the imports of Chilean nitrates, their value at Chile, the average value per 100 pounds at Chile and the export duty paid, and you see it totals $163,647,680.68.

The CHAIRMAN. Has this table been printed in any other hearing before?

Mr. BOWER. I think it was submitted to the House Committee in the hearings just recently held, was it not, Maj. Gaillard?

Maj. GAILLARD. Yes.

Mr. BOWER. It has not been printed, but it will be printed in the House hearings.

Senator RANSDELL. I would like to have this printed, unless it is going to be printed elsewhere. Let us have it printed in connection with Mr. Bower's testimony.

The CHAIRMAN. Without objection, let it be printed.

(The tabulation referred to is here printed in full, as follows:)

Nitrate of soda imports from Chile to United States.

[Statistics from Bureau of Foreign and Domestic Commerce, Department of Commerce.]

Fiscal year—	Long tons.	Value.	Average value per 100 pounds.	Export duty.
1867	13,150.00	$563,624.20	$1.92	(1)
1868	8,230.00	282,785.00	1.54	(1)
1869	12,900.00	600,691.00	2.08	(1)
1870	13,900.00	752,604.00	2.42	(1)
1871	22,400.00	1,254,963.00	2.49	(1)
1872	16,000.00	934,118.00	2.61	(1)
1873	26,700.00	1,469,243.00	2.46	(1)
1874	27,700.00	1,338,141.00	2.16	(1)
1875	23,300.00	968,855.00	1.85	(1)
1876	23,100.00	1,055,357.00	2.04	(1)
1877	24,300.00	1,324,299.00	2.44	(1)
1878	18,800.00	973,223.00	2.32	(1)
1879	34,100.00	1,348,880.00	1.76	$142,538.00
1880	30,400.00	1,830,396.00	2.69	380,912.00
1881	43,800.00	2,356,167.00	2.40	548,814.00
1882	82,300.00	3,911,610.00	2.12	1,031,219.00
1883	57,200.00	2,336,681.00	1.82	716,716.00
1884	54,000.00	1,983,378.00	1.64	676,620.00
1885	48,800.00	1,696,055.68	1.55	611,464.00
1886	45,100.00	1,681,824.14	1.67	565,103.00
1887	76,800.00	2,614,162.00	1.52	962,304.00
1888	80,000.00	2,449,639.40	1.37	1,002,400.00
1889	67,500.00	2,275,993.00	1.51	845,775.00
1890	91,300.00	2,709,130.72	1.33	1,143,989.00
1891	98,091.67	2,929,759.78	1.34	1,229,087.3721
1892	105,341.47	2,976,818.00	1.26	1,319,928.6191
1893	93,436.55	3,063,012.00	1.46	1,170,759.9715
1894	88,079.00	2,785,048.00	1.42	1,103,629.87
1895	124,803.00	4,124,712.00	1.48	1,563,781.59
1896	127,557.00	3,870,724.00	1.35	1,598,289.21
1897	83,331.00	2,640,389.00	1.42	1,044,137.43
1898	125,081.00	2,729,750.00	.98	1,567,264.93
1899	122,314.00	2,054,805.00	.75	1,532,594.42
1900	184,247.00	4,736,807.00	1.15	2,308,614.91
1901	203,609.00	5,776,566.00	1.27	2,551,220.77
1902	192,321.00	5,565,361.00	1.29	2,409,782.13
1903	252,084.00	7,737,405.00	1.37	3,158,612.52
1904	293,574.00	9,259,656.00	1.41	3,678,482.22
1905	282,229.00	9,683,396.00	1.53	3,536,329.37
1906	373,986.00	13,117,887.00	1.56	4,686,044.58
1907	342,073.00	14,041,202.00	1.83	4,286,174.69
1908	330,090.00	12,546,611.00	1.69	4,136,027.70
1909	353,494.00	12,583,417.00	1.58	4,429,279.82
1910	550,495.00	16,874,682.00	1.37	6,897,702.35
1911	546,525.00	17,101,140.00	1.40	6,847,958.25
1912	481,739.00	15,431,892.00	1.43	6,036,189.67
1913	589,136.00	20,718,968.00	1.57	7,381,874.08
1914	564,049.00	17,950,786.00	1.42	7,067,533.97
1915	577,122.00	16,355,701.00	1.26	7,231,338.66
1916	1,071,728.00	32,129,397.00	1.35	13,428,751.84
1917	1,261,659.00	44,231,240.00	1.57	15,808,587.27
1918	1,607,020.00	70,129,026.00	1.95	20,135,960.60
1919	1,346,679.00	68,229,548.00	2.27	16,873,887.87
	13,313,673.59	480,087,147.92	....	163,647,680.6827

(1) None.

Note.—The value given here is based on the value at the port in Chile, and does not include export duty paid to the Chilean Government, ocean freight, insurance, commissions, etc. Before 1914 freight from Chile to the United States was about $7.50 per ton; at the present time it is about $17.50. In 1879 an export duty was put on nitrate shipments from Chile and amounted to about $4.18 per long ton. In 1880 this duty was raised to $12.53 per long ton and has not been changed since that time. The export duty paid to the Chilean Government on all nitrate of soda coming to the United States up to July 1, 1919, would amount to $163,647,680.6827.

Mr. **Bower**. Of course, this was during the war period, when our importations were very high. In 1913 this same duty amounted to $7,381,874.08. The total bill of export duty which this Government has paid Chile on importations of Chilean nitrate is $163,647,680.68. Not only is this a Government monopoly fixing export duty of this character, but in the distribution and sale of Chilean nitrates it is handled entirely by an association called the Chilean association. It is composed of representatives of the major interests in Chile, principally British, and also two representatives of the Chilean Government, and this commission fixes the price for Chilean nitrates. In the hearing before the Committee on Expenditures in the War Department, part 54, serial 6, page 3551, the following conversation, Mr. Myers testifying, develops this point. Mr. Myers is the chairman of the United States nitrate committee, called in the United States the Chilean nitrate committee. He is its chief propagandist; that is his main work, to further the use of nitrate of soda:

> Mr. **Almon**. Who fixes the price of Chilean nitrate?
>
> Mr. **Myers**. The directorate of the association.
>
> Mr. **Almon**. The Chilean association?
>
> Mr. **Myers**. Yes, sir; in Chile.
>
> Mr. **Almon**. It is in the form of a trust of all of the producers of Chilean nitrate, and one of its purposes and functions is to fix the price of Chilean nitrate, as I understand you?
>
> Mr. **Myers**. Yes; but to stabilize the price is the word I prefer to use. "Fix" sounds arbitrary and as though you were attempting to squeeze somebody. I do not think it fair and proper to use the word "fix"; they are not extortioners or working in that sense at all.

It's fixed just the same. This question, I think, gentlemen, clearly demonstrates this situation. Mr. Myers, testifying before that committee, is director of the work of the Chilean nitrate committee in the United States.

Senator **Ransdell**. I do not get quite clearly who this Mr. Myers is. What interest does he represent?

Mr. **Bowers**. He represents the Chilean nitrate interests in this country.

Senator **Ransdell**. Is he connected in any way with the fertilizer companies of America?

Mr. **Bower**. I would not presume so, Senator Ransdell.

Senator **Ransdell**. Just the Chilean nitrate interests?

Mr. **Bower**. Just the Chilean nitrate interests.

The **Chairman**. Dr. E. Kilburn Scott told the committee there were several different corporations in Chile, some of them British. I presume Mr. Myers represents the British corporations?

Mr. **Bower**. He represents all of of them. They have a Chilean association down there which includes all of the producers.

Senator **Ransdell**. And his principal business is to induce the people of the United States to use just as much Chilean nitrate as possible?

Mr. **Bower**. Absolutely—a perfectly legitimate business propaganda, of course. He is in a position to know, and he testified that this Chilean Commission fixes the price.

The **Chairman**. I understand you take issue with Mr. Washburn in this, Mr. Bower. Mr. Washburn stated that the more of the compound manufactured at Muscle Shoals the more Chilean nitrate would be used.

Mr. BOWER. Absolutely.

The CHAIRMAN. You deny that altogether?

Mr. BOWER. I deny that on his own testimony, Senator Gronna, in 1916, where he proposed this very kind of plant and definitely stated to Senator Smith, when asked the question, that it would take the place of Chilean nitrate, and he argued it would reduce the price 50 per cent. And it was an ammonia nitrogen that he proposed to make. That was his point, that this ammonia nitrogen would not take the place of nitrate nitrogen. He proposed to make ammonium phosphate, and in 1916 he said that would replace the Chilean nitrates and cut the price in half, and in 1920 he says it will increase the consumption of Chilean nitrates.

In the past the price of all inorganic nitrogen compounds has been dominated by the price of Chilean nitrates, and the by-product coke-oven production of ammonium sulphate has made no serious endeavor to compete with Chilean nitrates on a price basis, but have simply sold their product at a price corresponding to the price of nitrogen in Chilean nitrates, so that we have had no real competition with this Chilean nitrate monopoly from within our own country. Bearing this out I would like to quote from the report of the nitrogen products committee of the Munitions Inventions Department of the British Government, which report has been so often referred to in the hearing preceding this:

> It is evident from the above figures that the supremacy of the Chile nitrate industry is already being challenged, and the near future holds out the prospect that ammonium sulphate or synthetic nitrogen products may become the dominant factor in the nitrogen market and govern the price of nitrate instead of following it as hitherto. (Par. 413, p. 83.)

These are the private interests, gentlemen, with one exception, which may be affected by the operation of this plant. The exception is the American Cyanamid Co., and the president of the American Cyanamid Co. has been before the committee and frankly states his motives in coming:

> Mr. WASHBURN. Now, our motive at this time is chiefly to defend ourselves from losing our property through Government imposition. That is the thing that confronts us. A second motive is to have our contract respected and lived up to by the Government, without the necessity of being obliged to defend ourselves in the courts. Because, in the very nature of things, we can not defend ourselves against the Government if the Government undertakes an act which we feel is unjust and in violation of our contract. It works out that way, for reasons I have already given in my testimony.
>
> We have another motive involved in this same consideration of self-preservation, and that is to find some way under which to achieve the very natural ambition that the Government and every right-thinking person has, to put that plant into operation.

And we do not deny that from his standpoint they are proper motives, but, gentlemen, we farmers believe that the United States Government will live up to any contract it has ever made at any time, and in this contract the American Cyanamid Co. is amply protected in royalties they receive, for these royalties, with this plant in production, amount to over $1,300,000 per year, which is 13 per cent interest on his own testified value of $10,000,000 of his plant, and was determined in conference to be an adequate protection to his industry. And it is very significant to us as to the profits made by the private interest engaged primarily in nitrogen production that 13 per cent interest on their investment will not cover the profits which they make on producing 60,000 tons of cyanamid annually. We farmers do not object to the whip of profits spurring on private interests, as Mr. Washburn states that they do; in fact, what we are aiming at is to place the American farmer so that he will have some profits to spur him on. But we do feel that in the production of nitrogen compounds they have not kept that whip to themselves, and it has been rather heavily played upon the backs of the American farmers.

With reference to the third motive of Mr. Washburn, his solution is to place this plant in a stand-by condition and to hold it idle until such time as his company feels that they can operate this plant successfully, at which time, with the proper arrangement, it should be turned over to his company. In analyzing this argument, we first find the flat contradiction of his representations before this committee in advocating the placing of this plant in a stand-by condition as compared with his testimony in 1916 before the Military Committee of the House. This contradiction has been called to your attention by the Ordnance Department, and I beg leave to again quote his 1916 testimony on this point:

> The staff that would steadily be employed in this plant would be 10 per cent to 12 per cent of the number that would be required in the event of war for its full operation. Chemical plants of this kind require a trained body of men; and in event of war threatening the country, we should have almost insuperable difficulty of training from green hands substantially 90 per cent of the requisite directing and working force. It is fairly a matter of grave doubt whether, under the unsettled conditions and excitement of approaching war and the exigent demands upon every one connected with the Army and Navy, such a plant could be placed in full stride in less than a year. It may be conceivable that a plant of this sort could be maintained in idleness without such a degree of deterioration as to render it useless, but it is highly improbable that it would be so maintained, and a country which should rely for its powder supply upon the practically indefinite maintenance in working order of an idle plant composed of highly delicate and complicated appliances would be taking a most extraordinary risk, which, if it can be avoided, would be wholly unwarranted. (Hearing before Committee on Military Affairs, House of Representatives, Feb. 11 and 28, 1916, p. 9.)

From his testimony also it is very evident as to when he considers this plant can take its place in the commercial world, and that is when according to his contentions the demands for nitrogen compounds will be so strong as to insure even with the operation of this plant the present high prices being maintained. You can hardly fail to reach this conclusion when his arguments for the protection of the ammonium sulphate production are taken into consideration. How opposite to his statement in 1916 in which he says:

> The fertilizer is essentially a labor-saving device. In every other industry, when we have high-priced labor, we turn to labor-saving devices. So that the low cost of an efficient fertilizer in unlimited quantities in this country will substantially help not only to reduce the cost of food, but will help to maintain the wage or the returns to the man in the field. (Hearing before Commitee on Military Affairs, Feb. 11, 1916, p. 25.)

The truth of the matter in our opinion is that realizing the impossibility of securing legislation or governmental action that would place this plant at his disposal now, at a price comparable to that received for "Nitro," he asks you to tie it up in a parcel and mark it with the name of the American Cyanamid Co. labeled in large letters "To be held until called for."

After having so carefully safeguarded the public interest in our great natural resources, the water powers on our streams, for the past ten years, and now with the development of the greatest single power producing site in the eastern United States, progressing as a governmental activity, and with the possibility of utilizing this power in the production of food because the production of cheaper nitrogen compounds means increased production of food, to at this time, I say, suggest that this entire development, built by the United States Government as a war measure, should be turned over to the private interests of the country, is a complete repudiation of your efforts to protect the interests of the public in these water powers in the past.

But furthermore, gentlemen, let us not forget that the American Cyanamid Co. is owned to a considerable proportion by British interests and the plant stands, unfortunately, on the other side of Niagara Falls in Canada. It is a Canadian plant that is so seriously disturbed about the operation of a plant in the United States.

In addition to this foreign ownership and foreign location of the plant, it is a licensee of a foreign corporation, an Italian one, for its processess. So we have an Italian licensee, partially owned in England, and operating in Canada, contending that its interests are more desirable of protection than the interests of the American farmer.

This is absolutely a clear-cut issue, gentlemen, between these great interests (and I want to review them for your inspection) and the farmers of the country. The United States Steel Corporation as represented in ammonium-sulphate production, for they are the largest by-product coke-oven operators in the United States, the products of which are sold with almost no exception by one central selling agency, the Barrett Co.; the great packing interests of the country, which are, according to their own testimony, so exceedingly deserving of protection by the United States Government; the southern cotton-oil mills—and, gentlemen of the committee, the packers have been reaching out to secure those operations in the South—and with this group of American interests are allied foreign interests, the Chilean nitrate monopoly and the American Cyanamid Co., which, though Mr. Washburn, asserts is not connected in any way with any fertilizer companies, nevertheless, by his own statement, owns the company that in 1918 mined 60 per cent to 75 per cent of all the phosphate mined in the United States and is closely associated with the Virginia-Carolina Chemical Co., one of the largest fertilizer combines in the United States; but their plant for the fixation of nitrogen, the only part of this organization that can claim to be affected by the operation of the Government plant at Muscle Shoals, is in Canada and pays taxes on its physical plant valuation in that country.

Senator **Ransdell**. Who besides the American Cyanamid Co. has complained against the Government's operating this plant at Muscle Shoals?

Mr. **Bower**. No one that I know of in open hearing.

Senator **Ransdell**. Are there any secret interests opposed to it, so far as you know?

Mr. **Bower**. Well, my own representatives in Virginia are getting some letters that are making them ask for me to come around and explain this proposition. They are getting letters from the fertilizer interests in Richmond and other places. I do not know just how serious that is, but it is an indication.

Senator **Ransdell.** The United States Steel Corporation, which produces all this sulphate of ammonia, is not conducting any active opposition to this?

Mr. **Bower.** They are not making any opposition that I know of; no, sir.

Senator **Ransdell.** Or the packers?

Mr. **Bower.** None that I know of, except that I think, through Mr. Washburn, these big interests are largely presenting their case. The argument for the ammonium-sulphate industry was a pretty fair argument for the United States Steel Corporation, I think. And the objection to the farmers' home mixing of fertilizers—that is the old standard Fertilizer Trust talk; we have heard that for years.

Senator **Ransdell.** However, ostensibly he represents only the American Cyanamid Co.?

Mr. **Bower.** Only the American Cyanamid Co.

Senator **Ransdell.** Which you say is largely a foreign company?

Mr. **Bower.** No; it would not be quite fair to Mr. Washburn to say that. But by his own testimony from 25 to 30 per cent of the stock is British owned.

The **Chairman.** He stated to the committee in answer to a question which I propounded, that the majority of the stock was owned by American citizens.

Mr. **Bower.** Oh, yes; I grant that. But the actual plant is in Canada and it is 25 per cent British owned, and it is operating under a license from an Italian corporation.

The **Chairman.** Of course, we really ought not to raise any objection to that, if it is serving a useful purpose here.

Mr. **Bower.** Oh, no; except just in this—and this is the principal point. Their plant for the fixation of nitrogen—the only part of their organization that they can claim to be affected by the operation of the Government plant—is in Canada and it is taxed on its physical plant valuation in that country, and it is between these interests and the interests of American agriculture seeking cheaper methods of food production that this committee must decide in its action on this legislation.

The Government has attempted to regulate such powerful combinations of capital as this through the Sherman Act, and I submit, gentlemen, that it has proven an entirely inadequate form of regulation, and especially does that apply to the manufacturers of nitrogen compounds when you realize that two of the interests in this combination are beyond the borders of this country. With such a situation, the operation of this plant is not socialism, but is practical Government regulation.

We do not think that we can make a better resumé of the argument so far presented than to quote verbatim the salient facts established by the nitrogen products committee of the British Empire, set out on page 133 of their final report, and on which their recommendation to the British Empire was based:

> In making the recommendations set out below, the committee has been guided by the following salient facts:
>
> (*a*) The sources of supply of combined nitrogen in the United Kingdom must be increased considerably if the existing and prospective home demands are to be met and the prewar scale of exportation is to be maintained.

(*b*) The existing sources of supply of combined nitrogen in the United Kingdom proved wholly inadequate for meeting the war demands.

(*c*) The risks and costs of importation during war are very serious.

(*d*) Combined nitrogen (as cyanamide or ammonium sulphate) can be obtained by synthetic processes at a cost, at the factory, which is less than half the market price of combined nitrogen from other sources, prewar conditions being taken as the basis in each case.

(*e*) Concentrated nitric acid can be made by synthetic processes for about half the prewar cost by the standard retort process via Chile nitrate.

(*f*) The ammonia oxidation process provides a means whereby, during a state of war, the importation of Chile nitrate would be rendered unnecessary.

(*g*) The world's demand for combined nitrogen appears to double every 10 years. The increased production during the war has not been more than the normal rate of increase during peace.

(*h*) The actual consumption of combined nitrogen for agriculture in the United Kingdom has practically doubled during the war, and there is certain to be a further increase.

(*i*) No very large increase in the output of by-product ammonia in Great Britain in the immediate future seems probable. (Par. 654, p. 133.)

and based on these facts the committee recommends that this process (the calcium cyanamid process)—

should be established in Great Britain without delay, either by private enterprise (supported, if necessary, by the Government), or as a public work.

Gentlemen of the committee, with these facts that have been presented showing the fundamental position nitrogen holds in the problem of soil fertility, we submit that this interest of the whole American people is entirely too great to turn over to a new nitrogen-fixation monopoly, especially when to establish it we must turn over our great water powers to their control, and is too great to longer allow it to remain in the domination of the Chilean interests and the Steel Corporation.

This brings us to the final consideration, and we wish to call your attention to what we believe is by far the most important phase of this whole question, and that is along the line of Dr. Lamb's testimony before this committee as to the experiment stations, the laboratory work, and the possibility that the future may hold in store for us and which has so ably been presented to this committee by Dr. Whitney, with his wonderful outlook into the future of fertilizer materials produced by the electric furnace. We believe that the possibilities of the application of the electric furnace to the production of fertilizer compounds may result in benefits which may surpass even the fixation of nitrogen itself. It was testified that in Germany the largest building in one of their nitrogen-fixation plants was a laboratory in which, at the time of that visit, there were engaged 75 chemists industriously working upon nitrogen and fertilizer compounds to be manufactured at these plants. We farmers want a larger laboratory and more chemists at Muscle Shoals than Germany has, and we have got to have them, gentlemen, if we are going to compete in food production.

Senator RANSDELL. May I ask right there, is that laboratory provided for in this Wadsworth bill?

Mr. BOWER. It is provided for in the Wadsworth bill.

Senator RANSDELL. The bill clearly provides for a large laboratory?

Mr. BOWER. A research laboratory. In testifying before the Senate Committee on Finance with reference to the protection of the dye industry, the following colloquy took place between Mr. Choate, the

American counsel of the dye industries, and Mr. Irenee du Pont, president of the E. I. du Pont de Nemours Co.

> Mr. CHOATE. That is what you have to have research chemists for; you have to have research chemists to help you?
>
> Mr. DU PONT. We can not get enough of them; they do not exist.
>
> Mr. CHOATE. How many have you?
>
> Mr. DU PONT. Of college graduate chemists between 400 and 500; some 460, I think, and of those, possibly 300 are concentrated on the dye industry, and others are scattered.
>
> (H. R. 8078, p. 160.)

The dye industry, important as it is, can not be considered of greater importance than the production of fertilizer elements, which is directly a question of food production.

Returning for the moment to the constituents of commercial fertilizer, nitrogen, phosphorus, and potash, you have been shown by Dr. Whitney samples of combinations of these materials that may be produced at Muscle Shoals by electric furnace methods. And most interestingly I have recently received three samples of just such combinations as he showed you from an entirely different source. The first is a material called ammonium phosphate, a combination of nitrogen and phosphorus, which material is identical except in the process used with the material proposed to be made by Mr. Washburn at this location of this water power in 1916, and which material he testified would reduce the cost of fertilizer to the American farmer 50 per cent. Also samples of super-phosphate so-called. carrying 50 per cent of soluble phosphorus combinations utilizable by the plant as food. The tremendous importance of a material of this kind is realized when it is considered that the most serious handicap to cheaper fertilizer for American farmers to-day is the very low percentage of plant food contained in the various elements now used in the mixing of commercial fertilizers.

Mr. Carruthers, who was an expert in the Department of Agriculture, is now working with the Southern Manganese Corporation, in Birmingham, where they are using water power in experimenting with the electric furnace, and these samples indicate some of the results they have obtained. One of their first and most striking results is the production of phosphoric acid in an electric furnace from the phosphate rock. What that means in fertilizer is rather technical, but it means the doing away with the use of sulphuric acid, which is one of the most objectionable features in mixed fertilizers and in the whole fertilizer business of to-day—the use of sulphuric acid in making these elements soluble. They have produced there a phosphoric acid by the electric furnace direct from phosphate rock, and they have combined it with ammonia to make ammonium phosphate. Mr. Washburn strikingly testified yesterday that he was making that, and had a plant at Hoboken for its manufacture. That is exactly the point, gentlemen; there is not a pound of that turned over to the American farmer. That is what these big interests do when they get these wonderful combinations. I do not know what these cost, the cost may be prohibitive, but you have got a plant down there where you can make these things and find out what they cost.

Senator RANSDELL. Is this [indicating sample] supposed to be a very valuable product?

Mr. Bower. Unquestionably.

Senator Ransdell. But you have no evidence to show how cheap it is?

Mr. Bower. No, sir.

Senator Ransdell. It may be very cheap?

Mr. Bower. It may be very cheap, and it may not be. Here is another more striking one. [Indicating another sample.] You heard Dr. Whitney speaking of the possibilities of potash. Here is a sample of 35 per cent water-soluble potash made in the electric furnace from the Georgia shales.

Senator Ransdell. Potash is one of the commodities of which we have an uncertain supply. We are trying to get it from kelp.

Mr. Bower. We are trying to get it from kelp. During the war we got some from deposits in the West, but the price was very high. We have in the past got it entirely from Germany, and now we will have competition between Germany and France, because France now has some of the potash mines in Alsace.

Senator Ransdell. This seems to have been made by the Southern Manganese Corporation. Have you any evidence from them to indicate what it would cost to make this?

Mr. Bower. Not a particle.

Senator Ransdell. Your theory is that if we establish this great chemical research laboratory all these things can be worked out by the Government, and if we get anything valuable it can be given to the American people?

Mr. Bower. Absolutely.

Senator Ransdell. Or to any enterprise that wants to carry them out?

Mr. Bower. Under proper Government regulation, etc.

The Chairman. Of course, you would have to use different processes from the one they are using at Muscle Shoals now in order to make use of this phosphoric acid, because that could not be used in connection with the cyanamid process. If I am not mistaken, this is what is used in connection with the arc process.

Mr. Bower. No; that is phosphoric acid, Senator.

The Chairman. I know, but where they manufacture nitric acid, in order to make that into a solid they use sulphuric acid to produce what they call saltpeter. That is what is being used, I understand, Col. Burns, in the Scandinavian countries?

Col. Burns. No, sir; I do not believe I understand it that way, Senator.

The Chairman. They manufacture nitric acid?

Col. Burns. Yes, sir.

The Chairman. They extract the nitrogen from the air in the form of nitric acid, and then make it into a solid, and in making it into the solid they have to use sulphuric acid.

Col. Burns. I did not know they were doing that now, sir.

Mr. Bower. They use limestone, Senator, to make calcium nitrate.

The Chairman. But they also use sulphuric acid.

Mr. Bower. If they do, they have got to get the phosphates from America.

The Chairman. The reason I call your attention to it, Mr. Bower, is this: They have the cyanamid process at Muscle Shoals. I am not raising any objection here or asking questions for the purpose of argument at all; I am just trying to follow what we are doing down there. We have machinery set up there for the manufacture of cyanamid?

Mr. **Bower.** And ammonia and ammonium nitrate, carrying it right on through.

The **Chairman.** Yes. Now, the question is, How many of these additional things can we make out of that product?

Mr. **Bower.** That is in the future, Senator. That is the purpose of this research laboratory; that is all. These things can not be made at the present time at Muscle Shoals. There is no question about that.

Senator **Ransdell.** I was just going to suggest this: You have wonderfully cheap electricity there at Muscle Shoals. Now, you do not know what that research laboratory is going to develop. It may develop a great many valuable things.

Mr. **Bower.** These [indicating samples] are samples of what it may possibly develop.

Senator **Ransdell.** If it is a fact, as you say, that the Du Pont people have between 400 and 500 chemists, do you suppose the Du Pont people are going to make known the products and processes which they discover?

Mr. **Bower.** Not at all.

Senator **Ransdell.** They will not give the American public the benefit of them?

Mr. **Bower.** Not at all.

Senator **Ransdell.** They are going to keep it to themselves, to make money out of it; at least I would if I were in their place. Now, if we establish a great chemical research laboratory at Muscle Shoals, whatever is worked out there will be for the benefit of the Government, and it can make it known. Suppose I were a chemical genius and had some very promising theories which I wanted to work out. Probably I could not work them out myself except by the expenditure of so much money and the use of so much power that it would not be possible for me to do it. Now, is it contemplated that in this Government plant at Muscle Shoals the inventive geniuses of America will be invited to come in and work under the auspices of Government authorities?

Mr. **Bower.** It certainly should be.

Senator **Ransdell.** That is in line with what you have in mind; is it?

Mr. **Bower.** Absolutely, Senator.

Senator **Ransdell.** That would give a wonderful opportunity for the development of genius, would it not?

Mr. **Bower.** Undoubtedly.

Senator **Ransdell.** You can get this phosphate rock right there in Tennessee?

Mr. **Bower.** Right in Tennessee.

Senator **Ransdell.** Where else do you get it? Is it in Florida, too?

The **Chairman.** There is a great deal of it in Wyoming, and all through the West.

Mr. **Bower** [indicating on map]. Here is Muscle Shoals, and here are the Tennessee phosphate fields immediately adjoining. This dam at Muscle Shoals furnishes navigable water into the Tennessee phosphate fields, making it possible to bring the phosphate right down to the plant. Over here are your potash shales. I have shown you here a sample of water soluble potash, made in the electric furnace from the potash shales.

This red indicates the navigation system of the Mississippi River—the Mississippi Valley. We have here 6-foot water navigation to connect it with that system. There never was a product better adapted to river navigation than fertilizer, because it is a seasonal product, the demand coming in the spring and fall. This will let the product go out by the cheapest transportation in the world to these various distributing systems. It can go up here to Omaha, to Kansas City, to Iowa, Illinois, Ohio, Pittsburg—by water. These barges can be towed through the Gulf and around through the Atlantic coast. Time is not an element in the proposition; cost is the whole thing. That is why the farmers wanted the plant located at Muscle Shoals; that is why a lot of us worked our heads off to get it put there.

Senator RANSDELL. If one private corporation can utilize the services of 400 or 500 chemists right now, trying to work out anything that can be done by chemistry, it seems to me beyond question that our Government ought to have somewhere a great research laboratory in which the inventive geniuses of this country could work out those things for the benefit of the whole Nation.

Mr. BOWER. This other map [indicating] is a map by the Engineer Department of the United States, showing river navigation. I have put on here in red the total amount of fertilizer consumed in the various States in 1913. You will see some surprising things there. For instance, look how this consumption is growing. Kansas is up to 9,460 tons; Missouri, 65,000 tons. Ten years ago they boasted that they had never used fertilizer and never would have to use it. What does that mean? It is an indication of soil exhaustion and a necessarily increasing demand for fertilizer.

Senator RANSDELL. What is New York using?

Mr. BOWER. New York is using 490,000 tons. There is an idea that this fertilizer is a southern proposition. Here are the three great consuming States—North Carolina, South Carolina, and Georgia. North Carolina uses 872,820 tons; South Carolina, 1,095,728 tons; Georgia, 1,282,000 tons.

Senator RANSDELL. How much in Alabama?

Mr. BOWER. Alabama, 592,200 tons; Mississippi, 127,000 tons. Look at Pennsylvania—381,900 tons; New York, 490,000 tons; Maine, 168,000 tons; Michigan, 60,000 tons. Out in the chairman's territory they used 550 tons in 1914.

The CHAIRMAN. It must have been used in gardening; I do not know of any being used for anything else.

Mr. BOWER. I do not mean that as a reflection upon your State, Senator; but it is an indication that if we are going to maintain our crop production we have got to come to fertilizer.

Here is a point about this superphosphate. That is a 50 per cent water soluble phosphate. The value of that is indicated in this way——

The CHAIRMAN (interposing). Where was this made?

Mr. BOWER. By the Southern Manganese Corporation, with which Mr. Carruthers is working. Acid phosphate, for instance, the most common form in which phosphorus is carried to the American farm, contains only 16 per cent of phosphate, while this sample carries 50 per cent. The saving in bagging, warehousing, freight, hauling, and the entire cost of distribution is at once evident. And the farmers of the country had definitely in mind the securing of just such results as these when in 1916 they insisted by resolution that the Government nitrate plants be located at Muscle Shoals, where there was this power and phosphate rock in immediately adjoining fields.

When we advocated the location of the plant at Muscle Shoals there was opposition. They even offered to put a plant in Virginia, to call off the Virginia Farmers' Union that was working so hard to put it down in Alabama. I think if Senator Martin could return he could very largely explain just how that plant came to be located at Muscle Shoals. He took the matter up with President Wilson himself and explained what the farmers were driving at and what they were trying to do, and that is how the plant came to be located at Muscle Shoals. That map shows why—cheap power, river navigation, phosphate fields immediately adjoining, and potash near-by. Limestone, one of the requisites, is right there also, and coke is shown by the map in the near-by southern coal fields.

It has been stated to this committee that the fertilizer industry of the country wraps up a great deal of intelligence in the mixing of its various brands for sale to the American farmer. But when it is considered that 80 per cent of the commercially mixed fertilizer that goes to the American farmer will average the content of 3 per cent ammonia, 8 per cent phosphoric acid, and 3 per cent potash, making a total of 14 per cent of plant-food elements, or 280 pounds in a ton of the material sold, we contend that this intelligence is mostly filler and that in order to secure the results of this intelligence we must pay the warehouse charges, the bagging, the cost of handling, the freight, and in turn haul over our muddy roads in the spring of the year 1,720 pounds of this intelligence filler in order to get 280 pounds of the plant food material we are endeavoring to buy.

The report of the Federal Trade Commission on the fertilizer industry, published in August, 1916, shows that this very company, which is a stockholder in the American Cyanamid Co., namely, the Virginia-Carolina Chemical Co., in the season of 1913–14, in one State—the State of South Carolina—registered 41 brands of 8–3–3 goods—that is, 8 units of phosphoric acid, 3 units of ammonia, and 3 units of potash—under its own name and 33 brands of 8–3–3 goods under the names of its controlled companies, making a total of 74 brands of fertilizers, substantially of the same composition, registered for sale in the State of South Carolina alone.

This is a very concrete illustration of the intelligence displaced by the fertilizer industry in marketing their product to the consumer and is complete evidence as to the low estimate they place upon the intelligence of the American farmer who buys their product, and if a further evidence of their contempt for his intelligence is desirable, the character of the representations that have been made to this committee by these fertilizer interests in their opposition to this legislation, we submit, is conclusive.

It is in the possibility of these researches, conducted in a great Government laboratory at Muscle Shoals, connected with the practical application of their discoveries in connection with a Government-controlled and Government-operated plant, with cheap power available, that we believe our greatest benefits are to be obtained. If these benefits are to be secured to the American farmer in producing food, they must be the result of research carried on by chemists who are working in the interest of the farmers of America and not in the interest of private industry. As a definite illustration of our thought along this line I wish to quote a paragraph from Robert Kennedy Duncan, late professor in the University of Kansas, who says about this matter in his book entitled "The Chemistry of Commerce":

> The present-day practical lesson of this whole strenuous successful work lies in the little object lesson it affords of the immense importance which technical science is assuming in our daily lives and in all our industrial operations. The substitution of real knowledge and high technical skill for the "rule of thumb" of our ancestors has created a revolution in industry. This revolution took its rise in Germany, and it is spreading rapidly to every corner. It is spreading silently, too, *because it does not pay to tell.* During the next five years the small manufacturer who is swept out of existence will often wonder why. He will ascribe it to the economy of large-scale operations, or business intrigues, or what not, never knowing that his disaster was due on the application of pure science that the trust organizations and large manufacturers already are beginning to appreciate.

This the method of these big chemical industries in maintaining their supremacy in the field. This committee can bear witness as to the difficulty in obtaining costs of air fixation of nitrogen, and at present there is no information in this country as to the cost of manufacturing aluminum and other electric-furnace products. The policy of the aluminum company is absolute secrecy as to their processes and costs. Since the future of this Government depends upon the prosperity of the agricultural interests engaged in producing the food and clothing of the country, this question, so closely related to food production, is removed entirely from a consideration in which the interests of private corporations and their profits are paramount.

These great resources of the country—the water powers—can not better be utilized than, through governmental activity, be harnessed for the service of all the people in the production of the necessary elements required for food production, and Theodore Roosevelt must have visualized the problem that this committee is called upon to solve to-day when he wrote in the Outlook of September 7, 1912:

> The Government must cooperate with the farmer to make the farm more productive. There must be no skinning of the soil. The farm should be left to the farmer's son in better and not worse condition because of its cultivation. Moreover, every invention and improvement, every discovery and economy, should be at the service of the farmer in the work of production.

You have a simple decision to make, gentlemen of the committee. The door is open through the operation of this plant to free the American farmer from the burden of paying the high prices of the past for nitrogen compounds, and further to secure results which have been clearly demonstrated to this committee as entirely possible in the matter of producing higher and better grades of phosphate and potash fertilizers, and the choice you must make is whether you will hold this door open and insist that these wonderful possibilities shall be made available to the American farmer in the producing of food, or you will close this door in the face of the need and demand of the public welfare, and hand the key to the corporate interests of the country to maintain their monopoly and their profits.

The CHAIRMAN. Do you desire to ask Mr. Bower any questions, Mr. Ransdell?

Senator RANSDELL. I understand the du Pont people are working on something else besides the coal-tar dyes?

Mr. BOWER. Oh, yes.

Senator RANSDELL. I understand they are making very elaborate investigations, and that they have already expended $15,000,000 trying to find a cure for tuberculosis. They are emulating Mr. Rockefeller in efforts to eradicate the hookworm and all that sort of thing.

Mr. BOWER. They are making automobile tops, imitation ivory, and a hundred and one other products.

Senator RANSDELL. It is a very remarkable chemical laboratory, is it not?

Mr. BOWER. Undoubtedly.

Senator RANSDELL. And one that ought to benefit mankind very much. I understand there is also a very remarkable laboratory at Schenectady, N. Y., conducted by the General Electric Co. I am somewhat familiar with that, having been educated at Union College. It is a very remarkable enterprise. Now, the purpose here is to have a great Government laboratory?

Mr. BOWER. The point is this: That agriculture can not carry on a laboratory like that.

Senator RANSDELL. Of course, it could not. Agriculture is not big enough to do it.

Mr. BOWER. And if you turn that over to these private interests you do not get the results. There is the instance of the ammonium phosphate produced by Mr. Washburn, and shipped abroad.

Mr. Chairman, Mr. Atkeson, I think, desires to make a statement.

The CHAIRMAN. I think we should take a recess now.

Mr. ATKESON. It will not take me very many minutes, Mr. Chairman. If you will give me 10 minutes I will agree to get through.

STATEMENT OF MR. T. C. ATKESON, WASHINGTON REPRESENTATIVE OF THE NATIONAL GRANGE.

Mr. ATKESON. Mr. Chairman and gentlemen of the committee, my name is T. C. Atkeson. I am a practical farmer and am at this time the Washington representative of the National Grange, an organization of farmers which has been in continuous operation for 53 years, and is the oldest and most conservative farmers' organization in existence. I has a dues-paying membership of approximately 750,000 and several hundred thousand other members who, from one cause and another are temporarily dormant. Personally, and on behalf of this organization which I have the honor to represent, I desire to make a brief statement in support of the bill now under consideration, or such modification of it as may be deemed necessary to most effectively and efficiently continue the operation of the Government nitrate plant at Muscle Shoals, Ala.

We are in Washington in a spirit of helpful cooperation in our efforts to place before Congress and the various departments the true farmer's viewpoint of the food production problems which are now receiving so much attention, and upon which the welfare of all our people so largely depends. In this spirit of helpfulness we go over these rural problems with the Members of Congress and with congressional committees who have charge of the measures affecting the interest of agriculture, in order that we may, if possible, assist them in arriving at a fair and unbiased understanding of the problems and the points of view of real farmers.

One of the things in which we farmers are always deeply interested is the fertilizer question, as you may see from this action taken by the National Grange at its last session, which was last November, as follows:

> In many sections of the country the use of fertilizers is now a vital need in the production of crops. Any policy which will supply an adequate supply of phosphoric acid, nitrogen, or potash at moderate cost will benefit agriculture and all the people. Already the necessary machinery has been provided, largely at Federal expense. This machinery, if properly turned from war to peace channels, can be made to provide all necessary fertilizer materials cheaper than ever before. The plants used for the production of sulphuric acid for munitions may easily be continued, that the unlimited stores of rock phosphate may be converted into acid phosphate at a minimum of cost. The nitric acid plants established by the Government for the production of gunpowder should be converted into nitrate plants for the production of nitrogen for fertilizer, thus freeing the Nation from dependency on foreign supply. Of equal importance is the development of methods of securing potash of domestic origin.

This is by no means a farmers' problem only, but is of equal or greater importance to the consumer, for the more farmers pay for their fertilizers the more the consumers must pay for their food products. With the increasing cost of production the price of farm products must continue to increase. Somehow "farming must be made as profitable as any other occupation involving the same amount of investment, business ability, and hard work, or our democracy must fail and our people go hungry."

Any shortage in supply or any increase in the price of nitrogen used for fertilizer must somehow manifest itself in the increased cost of agricultural products, and, judging from the hue and cry about the high cost of living, the people who live in the cities are even more vitally interested in an adequate supply of cheap fertilizers than the farmers are.

All the farmers' organizations in the country favor the continuance of the Muscle Shoals nitrate plant, and so far as I have seen any expression in the agricultural press, it indorses the same proposition. Numerous editorials have dealt with the question. I shall quote but one, from the American Agriculturist of April 24, as it is typical:

> The queer impression appears to be making headway in Congress that nitrogen is so little needed in agriculture, its use should be increased but slowly. At recent hearings it has been emphasized that the improved type of coke oven now saves in the form of sulphate of ammonia the nitrogen which formerly was wasted. But "any reduction from present high prices of this coke by-product will have to be compensated for by higher prices for iron and steel." This claim is enough even to make a horse laugh. If steel sold lower when the nitrogen in coal was lost by wasteful coking, steel ought to sell still lower when its nitrogen by-product is secured at so small a cost that any price at which it may be sold ought to represent reasonable profit.
>
> In the questions and answers before the congressional committee that has been investigating the Government nitrate plant at Muscle Shoals, there crops

up frequently the apparent fear this this vast nitrate plant, if run on business principles by a Government corporation, free of red tape, may be able to furnish nitrogen at lower prices than in other forms of nitrogenous substances. If fertilizer manufacturers and farmers are thus furnished with cheaper nitrogen, the fear also is expressed at Washington that this may put up the price of steel and iron, or result in accumulating nitrogen faster than it can be used. All of which is enough to make even a mule laugh.

No greater blessing could be conferred upon food producers and food consumers than to have nitrogen become available for plant food in unlimited quantities at low prices. Every pound of it would be quickly used by progressive farmers. They never have been able to get nitrogen enough, regardless of price. Where one pound of dear nitrogen is now used for plant food, 10 pounds or 100 pounds would be employed if it were cheaper. Instead of arbitrarily restricting the production of nitrogen, whether for the benefit of iron and steel or for exporters of nitrate from Chile, let the United States make every reasonable effort to increase its domestic supply of nitrogen—not only by saving the present industrial wastes of nitrogen, but also by vastly increasing the fixation of atmospheric nitrogen.

If Washington would only be as solicitous to upbuild agriculture as it to safeguard the unprecedented profits of labor and capital in iron and steel, fertilizers would be cheaper, the cultivated area larger, food more plentiful, and food prices lower. Incidentally, too, this policy would insure the United States ample nitrogen for defense or offense in war.

Why all these obstacles to the nitrogenous independence of the United States in peace or war? Why this effort to align fertilizer manufacturers against cheaper nitrogen? They want cheaper raw material just as much as do the consumers of fertilizers. Lower prices per unit of nitrogen, phosphorus, and potassium would enable manufacturers to double and treble their sales of fertilizer. Indeed, the fertilizer industry is still in its infancy, compared to the insatiable demand that awaits its products.

Now, gentlemen, I had prepared a long statement covering in large measure the ground gone over by Mr. Bower. Practically every word of his statement I want to indorse. With this brief statement I am through, unless you wish to ask some questions. I do not want to duplicate the splendid statement he has made. You have heard a great deal of technical discussion of this subject, which I had intended to inject into the record, but it seems to me it is so absolutely unnecessary I am satisfied to rest here.

Senator RANSDELL. I understood you to say that your association was strongly in favor of this Wadsworth bill?

Mr. ATKESON. Yes.

Senator RANSDELL. You believe it ought to be passed? Or some bill embodying the general idea?

Mr. ATKESON. Either this bill or some modification of it that may be necessary to continue the operation of the Muscle Shoals plant for the production of nitrogen for fertilizer purposes.

Senator RANSDELL. How thoroughly has this matter been presented to the farmers of the country? To what extent have you sought to get their views on it in order to speak intelligently for them?

Mr. ATKESON. Replying to your first question, as to how thoroughly it has been presented, the agricultural press for the last four or five years, since 1916, has been carrying editorials and long discussions. I read a splendid discussion of the subject in the Country Gentleman only a few weeks ago. So I think that in a general way you may say they are pretty thoroughly informed as to the necessity for an increased quantity of nitrogen fertilizer.

The only point on which I have ever heard any doubt expressed was as to whether it was a legitimate Government activity to continue this plant at Muscle Shoals. So far as I know there has been an almost universal agreement that it is a legitimate Government activity, because of its experimental features, if nothing else. The investment has already been made at Muscle Shoals, and even if it were not possible to produce nitrogen commercially at a price cheaper than it can be secured from some other source this plant should be continued to determine whether it is possible to secure all the supply in that manner. It is still in an experimental stage. It is just possible that the time may come when our entire nitrogen supply for fertilizers will be secured more cheaply from the air than from any other source. If that can be done we need not worry about the waste of the coke ovens or the failure to get Chilean nitrate. And whenever it is demonstrated that it can be produced commercially more cheaply through some of these scientific processes private enterprise will engage in the business; and if they can operate more efficiently than a Government plant, as most of us believe—at least I believe they might do so—I think that on that ground alone practically every farmer in this country who has studied the question at all believes that it is a legitimate Government activity at this present stage of atmospheric nitrate development.

Senator RANSDELL. Doctor, what do you think of the wisdom of having a great chemical research laboratory carried on in connection with this plant? I understand that is part of the scheme for developing these projects which have been stated here to us by Mr. Bower, and possibly many other projects. Do you consider that as of very great importance?

Mr. ATKESON. Yes; it is, I would say, of first importance.

Senator RANSDELL. Why?

Mr. ATKESON. Because we are now in the experimental stage of development of securing nitrogen from the atmosphere. It has only been comparatively a few years, perhaps 25 or 30 years, since it was possible to secure the atmospheric nitrogen which exists around us in such great abundance. By a continuation of these experiments in a great governmental laboratory it is possible we may discover the means by which this atmospheric nitrogen may be secured very much more cheaply than we have been able to secure it up to this time. For that reason, it seems to me, it is of the first importance because of its possibilities.

Senator RANSDELL. How about potash? This sample seems to have been produced from Georgia shale in an electric furnace, using hydroelectric power. Would it not be of immense value to this Nation if we became entirely independent of Germany and of France, too, now, for our potash through development in our own country?

Mr. ATKESON. Unquestionably.

Senator RANSDELL. Mr. Bower stated that the Georgia shale contained this potash and that they were developing it down there by an electrical process, but that it has not yet been demonstrated to be a success; the cost of it has not been brought out.

Mr. ATKESON. That all goes along with the laboratory that you speak of. We can not get potash from the atmosphere, however.

Senator RANSDELL. Not from the atmosphere, of course, but we can get it from the shale. I believe all earth has more or less potash in it, has it not?

Mr. **Atkeson**. Except sand.

Senator **Ransdell**. A rich soil, such as we have where I live, contains lots of potash. Perhaps we may develop a process by which we can take it out of the ground. I understand the aluminum people get aluminum out of practically any soil. They have been developing enormously. Now, the label on this sample says: "Ammonium phosphate, containing 14 per cent ammonia and 30 per cent water soluble phosphoric acid"—which I understand is a very valuable combination—"produced by treating phosphoric from the electric furnace with ammonia." Why can we not develop something of that kind in this great chemical laboratory?

Mr. **Atkeson**. Possibly we can.

Senator **Ransdell**. That is immensely valuable to agriculture, just the same as atmospheric nitrogen, is it not?

Mr. **Atkeson**. Potash is one of the three essential elements of fertilizer.

Senator **Ransdell**. And phosphoric acid is the third. So you believe that the chemical laboratory is the most important thing connected with the whole matter?

Mr. **Atkeson**. With reference to the future, of course.

Senator **Ransdell**. I mean, with reference to the future.

Mr. **Atkeson**. The possibilities for the future.

Senator **Ransdell**. I have no further questions.

Mr. **Atkeson**. I have consumed my time.

Mr. **Bower**. Mr. Chairman, Mr. Lyman, of the National Board of Farm Organizations, desires to present some resolutions.

There are only two of these gentlemen, Mr. Chairman, and they only want to submit some resolutions.

Mr. **Lyman**. I just want to put these on record. It will not take more than two or three minutes. I understand the same is true also of Mr. Frame.

The **Chairman**. Very well.

STATEMENT OF MR. CHARLES A. LYMAN, SECRETARY NATIONAL BOARD OF FARM ORGANIZATIONS, 1731 EYE STREET NW., WASHINGTON, D. C.

Mr. **Lyman**. Mr. Bower has submitted the case of the National Board of Farm Organizations. He is chairman of the Fertilizer Committee which was appointed at the last conference, which we held in Washington on February 19–20 of this year.

Our first resolution bearing on the Muscle Shoals project was adopted August 29, 1918, it is as follows:

"Whereas the building of the great nitrate plant at Muscle Shoals, together with the water power which will make these plants available in time of peace for the manufacture of cheap fertilizer, is the one outstanding feature of necessary war development that will have a permanent influence upon the agricultural industry of the country; and

"Whereas we hear with regret that work on this dam has been suspended and thus prevents the realization of the hopes of the farmers that the product of these plants might be available during the reconstruction period at the close of the war, when it would be most valuable—

"Therefore we most respectfully appeal to the President of the United States that some method be adopted by which this work can be at once resumed, if consistent with the effective prosecution of the war, with priority orders if necessary only for such material as will be required for the construction that can be accomplished at once, so that these plants with their potential possibilities shall not be idle when their product is no longer needed for destruction, but can at once become an asset of the Government and of vital assistance to the farm lands of the nation that have been and will continue to be called upon to yield and yield again that man may be fed."

That was the first action taken by the National Board of Farm Organizations. The last resolution is shorter than that. This was adopted February 20, 1920:

> Whereas the war emergency needs for nitrogen compounds for explosives resulted in the building at Muscle Shoals, Ala., of an immense plant for fixing nitrogen compounds from the air; and
>
> Whereas careful estimates of the War Department show that this plant can make an important contribution toward a larger and cheaper supply of nitrogen compounds for fertilizer; and
>
> Whereas this plant is now idle and action of Congress is required before it can be operated, and whereas a bill has been introduced for this purpose. Therefore, be it
>
> *Resolved*, That the National Board of Farm Organizations appoint a permanent fertilizer committee, with power to call in such additional assistance as may be needed, to support proper legislation providing for well-considered Government operation of the nitrate plants at Muscle Shoals and to look after such other fertilizer matters as may vitally affect the interests of American agriculture.

Mr. Bower is chairman of that committee and I am a member of it. As secretary of the national board I want to emphasize the point that Mr. Bower has stated the views of the farm organizations belonging to this national board.

Senator RANSDELL. You endorse everything he said?

Mr. LYMAN. I endorse what he said, and believe he has made a very valuable contribution to the farmers of the country and to the measure which is before this committee for its consideration.

I thank you, Mr. Chairman.

STATEMENT OF MR. NAT T. FRAME, REPRESENTING THE AMERICAN FARM BUREAU FEDERATION, WASHINGTON, D. C.

Mr. FRAME. Mr. Chairman, I am speaking in behalf of Mr. Gray Silver, the Washington representative of the American Farm Bureau Federation. At its meeting in March, at Chicago, the American Farm Bureau Federation adopted this resolution:

> We pledge the farmers of America to the largest possible production consistent with good husbandry, with a view to relieving the world's dire necessities, and invite the workers of all other industries to join us in this spirit of conservaton.

Then, after a hearing the report of a committee on investigation of the Muscle Shoals plant, read by Mr. D. O. Thompson, secretary of the Illinois Agricultural Association—on this committee were several scientists from the agricultural colleges—the American Farm Bureau Federation passed this resolution:

> We support the measure pending in Congress looking toward the operation of the nitrate plant No. 2 at Muscle Shoals for the production of ammonium nitrate.

May I just add that the Government has for a number of years been investing public funds and giving public supervision to this matter of obtaining atmospheric nitrogen, through the work of our experimentations and of the Department of Agriculture, in working out methods of farming which include nitrogen fixing crops—legumes—but that in many large sections of the country the use of legumes is limited by the acidity of the soil, and that in large areas of the country to secure lime to correct that acidity is a very difficult and very expensive matter. Many soils that otherwise would be very productive are now not productive because of the impossibility of getting lime, even under our system of rotation which would take atmospheric nitrogen from the air.

Some of the States have recognized that problem as a proper matter for governmental activity, and the State of Illinois, I understand, operates State lime plants to furnish lime to the farmers at cost of production. The State of Virginia does likewise. The Sate of Virginia has also fixed a freight rate on lime, looking to the very object that we have in mind in the establishment of this plant to furnish nitrogen. But so many millions of acres can not be put into profitable production through the use of legumes, on account of the impossibility of getting lime, that this atmospheric nitrogen, which can be brought in concentrated form with a comparatively low freight rate and comparatively cheap transportation, will make productive for food purposes millions of acres in what we would call the less productive sections at the present time.

I thank you, gentlemen.

Senator RANSDELL. You indorse the general idea of the bill, I take it?

Mr. FRAME. Yes, sir. The organization that I represent, comprising about 1,061,000 farmers at this March meeting——

Senator RANSDELL (interposing). Scattered over the country generally?

Mr. FRAME. Twenty-eight States being represented, in all parts of the country—officially indorsed, as I read there, the operation of this plant No. 2. They even had an investigation committee of their own membership, who spent some time looking into it, and that committee naturally was listening to the objections that might be raised, and made their report with that in mind.

Mr. BOWER. I might state that that committee visited that plant at Muscle Shoals.

The CHAIRMAN. Let me ask you one more question, Mr. Frame. You stated that the farmers pledged themselves to certain things. What did the organization guarantee to the farmer? Anything? I will state the reason I am asking that question: I want to be perfectly frank with you. I have always had the idea that the greatest factor in stimulating production was to insure the farmer that it would be profitable. What are your organizations doing for the farmer in that respect?

Mr. FRAME. A great many different things, Senator. It would be rather difficult for me to explain just what. The Farm Bureau Federation is doing the best it can to assist in working out marketing problems from the farmers' point of view in order to make farming economically profitable.

The CHAIRMAN. If you are a practical farmer you know that very often when the farmer produces 2,000 bushels of grain he will get less for the 2,000 bushels than he will get at times for 1,000 bushels. Are you taking those things into consideration?

Mr. FRAME. I am very sure that was taken into consideration at the time the resolution was passed.

(Subsequent to the close of the hearing the following letters were received and by order of the chairman are here printed in the record as follows:)

THE NATIONAL FERTILIZER ASSOCIATION,
Baltimore, May 14, 1920.

Hon. ASLE J. GRONNA,
Chairman Committee on Agriculture and Forestry,
United States Senate.

DEAR SIR: On behalf of the fertilizer industry I beg leave to file with your honorable committee the following brief setting forth our views as to the dangerous effect of the bill S. 3390 to the fertilizer industry.

The fertilizer industry, manufacturers and distributors of agricultural chemicals, doing a business this year of over 7,000,000 tons; with manufacturing capacity considerably in excess of that tonnage; operating approximately 1,200 plants throughout the United States; with mines producing raw materials for fertilizers; with a capital investment in excess of $300,000,000; extending crop time credit to farmers on approximately 65 per cent of the tonnage shipped; borrowing largely at its risk of bank depositors' savings that the business may be properly financed; willing up to now to anticipate the further needs of our agriculturists by planning and constructing facilities ahead of the demand and fully able to supply the needs of the farmer for agricultural chemicals—is vitally interested in the policies disclosed in Senate bill S. 3390 and House bill 10329, entitled "To provide further for the national defense; to establish a self-sustaining agency for the manufacture, production, and development of the products of atmospheric nitrogen for military, experimental, and other purposes," etc., and authorizing the Government to dispose of the products made to "producers or users of fertilizers or to others."

This bill provides that the United States enter into the manufacture, in peace times, and distribute to "users" agricultural chemicals and other products in competition with private manufacturers now so engaged. The policy involved is revolutionary and illusionary in its character and if carried out will tend toward the upsetting and socialization of an important, privately developed industry tying into many sanitary, metallurgical, and by-product side lines. It carries with it the element of unfair competition in that it provides for a Government manufacture and sale without the inclusion of important elements of cost which the private manufacturer pays. We refer specifically to the elimination of all taxes, Federal, State, and local, and to the relief of charges of interest, depreciation, and amortization on capital which must be figured in private manufacture as examples of the point we are making.

The production of agricultural chemicals, carbide of calcium, and possibly commercial explosives at Muscle Shoals, Ala., with the impossibility of general national distribution from one point, would result in discrimination in favor of users located near the point of manufacture as against the farmer or other consumer living in other parts of the United States. A further result would be that other sections possessed of water-power sites they would like to develop at taxpayers' expense would insist on the location of similar plants in their neighborhoods. The ball once started rolling would be difficult to stop and another "old man of the sea" would perch on the shoulders of the unfortunate taxpayer, as, irrespective of profits or losses, Government bureaus seldom die and never resign.

The fertilizer manufacturer was fully in sympathy with the policy adopted by the Government during the war to manufacture a portion of the nitrogen compounds needed in the very exceptional and unusual explosive program due to the difficulties and dangers incident to the shipment of large quantities of nitrate of soda from Chile.

Allied Governments were dependent on our manufacture for supplies. He approved heartily of Government finance extended to by-product coke manufacturers to build additional ovens to provide for a larger manufacture of nitrogen compounds and the as fully important toluol and benzol needed for the making of explosives of a character different from those manufactured at Muscle Shoals. He sympathizes with the serious study made by the Government for the utilization in the general interest of Government-built war plants. but he does not agree with the policy of using these plants for the manufacture of retail civilian wants in competition with private capital and fears that, should this policy be adopted, with the resultant hesitancy on the part of capital to further engage in the manufacture of agricultural chemicals and other products, the farmer and other users of such products would fall between the two stools of private and Government manufacture and not receive the materials so vitally needed in the production of field crops and in the doing of other important things.

The manufacture and distribution of fertilizers is one which, owing to the long season of manufacture and storing and the short season of shipment, must be carried on in a large number of plants well distributed throughout the consuming sections. Our inadquate car supply renders it difficult to-day to properly accumulate and distribute the farmers' needs from the many plants in existence. These difficulties would be greatly enhanced if large Government plants were to be added with all of the congestion in transportation and delay in delivery which comes from a too large manufacture at any one point. The tendency of fertilizer manufacturers to insure quick distribution is against few large plants and toward more smaller plants located in the consuming sections at a low freight-distribution cost.

The fertilizer manufacturer does not agree with the policy that to further the national defense it is necessary for the Government to engage in many years of peace-time making of fertilizers in competition with private capital to insure the making of some of its explosives materials in Government-owned fertilizer plants when war comes. He does not think it good business to spend more taxpayers' money to develop the making of sulphate of ammonia at Muscle Shoals, as the product is not needed, nor does the process used appeal to him as having permanence enough in scientific life to warrant more good money being sent after what has been put in. The trend of scientific development is away from huge electric power consumption methods and toward less expensive and more cunning, power-saving processes. He does not think it is in the interest of conservatism of coal, transportation, capital, and labor that coal already in short supply in that section, be dug and shipped to Muscle Shoals to run a big steam power plant, that coke needed for other purposes be consumed, that lime be quarried and loaded into cars which could transport coal to industries needing coal, and that an army of men, more useful in other places, be diverted to the manufacture of articles already produced by existing industries beyond the present needs of the country. The proposed investment is merely a starting post and $35,000,000 can easily be spent in the development of this one scheme, with the probability of having, when finished, about as efficient and up to date a producer and competitor on a real cost basis as a third-class battleship would be in a fight with a modern dreadnought.

We feel we are safe in saying that there has been no shortage this year of the particular form of nitrogen it is proposed to manufacture at Muscle Shoals and that a study of the situation would show that the make of sulphate of ammonia, notwithstanding steel and coal strikes and transportation difficulties, has been large enough to take care of the demand for that particular type of nitrogen and to permit of an export of a limited tonnage to countries sorely in need of this material for the growing of food and field crops. At no time in the history of the world has there been so great a nitrogen producing capacity in the various countries as exists to-day and when Europe settles down and goes to work they will have a large exportable surplus which can easily be availed of in case of necessity. Nitrate of soda, which has a particular field in the agriculture of the United States, can be produced in Chile in plants now built in excess of the world's needs and with the probability that there will be a further reduction in the demand for nitrate from Europe. Sulphate or other forms of ammonia do not take the place of nitrate of soda in supplying certain of our agricultural needs or in making certain important explosives and it is not proposed to make nitrate of soda at Muscle Shoals. It can be made if cost is disregarded, but it would not be good sense to do so.

We believe that private manufacturers who are bound to use modern processes, together with by-products coke interests and others, can better and more justly supply our needs than can the Government, and that it can be accomplished at less capital expense and with less man power. We also feel that it is good national business for the industries of the United States to make reasonable purchases of nitrate of soda from Chile in the interests of general trade relations and that the Government, to be prepared for emergencies, should carry a large stock of nitrate of soda in arsenals as a definite settled policy.

If these two plans are followed, we have no doubt but that an adequate supply of explosives materials can be secured to meet any national need, and that the peacetime requirements of our manufacturers and farmers can be met. There is no likelihood of a monopoly in these commodities in this country, as the coming surplus production of Europe and Chile will have free entry into this country as called for and prevent any monopoly.

We feel the Congress should encourage the further development of the agricultural chemical industry by private initiative and not stunt or destroy its growth by passing legislation of the character proposed in the bill under discussion.

Respectfully, yours,

W. D. HUNTINGTON, *President.*

WASHINGTON, D. C., *May 14, 1920.*

Hon. ASLE J. GRONNA,
United States Senate, Washington, D. C.

MY DEAR SENATOR: I testified before Senate Committee on Agriculture and Forestry April 27, 1920, that in my best judgment the Wilson dam and power plant would involve the Government in an expenditure of $50,000,000.

My attention has just been called to a letter of May 1, addressed to you by the Secretary of War, transmitting an estimate from the Chief of Engineers, dated April 17, 1920, and setting forth an estimated cost of $29,290,000 ($16,737,000 plus 75 per cent) for the Wilson dam and power plant.

The Chief of Engineers bases his estimate upon figures made in the fall and winter of 1915 and spring of 1916 and contained in a report from the office of the Chief of Engineers to the Secretary of War set forth in House Document No. 1262, Sixty-fourth Congress, first session. The Chief of Engineers selects from that estimate 13 items, the sum of which is $16,737,000, and adds 75 per cent thereto to account for the average excess in prices at this time compared with the time that the original figures were made. This gives a total of $29,290,000. But the Chief of Engineers in his report of April 17 to the Secretary of War failed to include seven items, all of which are absolutely necessary expenditures in order to complete the Wilson dam and hydroelectric power plant, namely, (1) power-house superstructure; (2) outdoor substation; (3) stop logs; (4) engineering on equipment; (5) administration chargeable to construction and installation of equipment; (6) contingencies on equipment; (7) interest on funds as supplied from time to time for construction.

The total of the first six items as set forth in Document No. 1262 is $6,067,000, which added to the $16,737,000 amounts to $22,804,000. If to this we add 75 per cent, we have a sum of $39,908,000. If to this latter amount we add interest during conconstruction, which I estimate to be not less than $3,280,000, we have a total of $43,188,000.

In other words, had the Chief of Engineers included all the necessary items (instead of only a part) in the amounts given in Document No. 1262, and added three-fourths thereto, as was his method with the items which he did include, and to this amount had added the necessary interest during construction which the Government must pay out of its pocket, his estimate instead of being $29,290,000, would have been $43,188,000.

We believe, however, that this amount is insufficient to complete the work under the conditions which surround it, for the following reasons:

1. The figures in Document No. 1262 are based on the dam and power plant being constructed by contract, under the direction of private interests and not by the Engineering Corps under force account. The engineer officer in transmitting the figures in Document No. 1262 gives numerous reasons why the work can be done cheaper by contract than by Government force account.

2. Labor, measured by its efficiency, and the prices of materials and equipment have increased since the figures of Document No. 1262 were made by not less than 100 per cent and possibly more nearly 150 per cent. So we consider that adding 75 per cent to the figures of Document No. 1262 is wholly inadequate. Extensive estimates covering a number of hydroelectric power projects which have just been completed show with practical unanimity that the cost of completed work to-day is two and a half times the normal prewar cost.

3. The Chief of Engineers forecasts the placing of the power generators in operation January 1, 1922. This we believe to be not only impracticable but absolutely im-

possible. Only a part of the stream bed has been uncovered and no concrete has been laid in a permanent structure. In this connection we call your attention to the testimony given by Mr. Hugh L. Cooper, hydraulic engineer, of New York, before subcommittee No. 5, House of Representatives, Committee on War Expenditures. February 3, 1920, in which he states that it will be the 1st of January, 1925, before the dam can be completed. During the war Mr. Cooper had charge of the construction of the Wilson Dam. Bearing these facts in mind we believe that our rough estimate given before your committee of substantially $50,000,000 as the cost of the Wilson dam and power plant is not excessive.

I should like to call to your attention the fact that the Government, judging from the statements contained in the Chief of Engineers' letter to the Secretary of War, under date of April 17, 1920, is proceeding with the construction of this great work without a distinct estimate, and possibly without an estimate much better than a guess as to what the cost will be under present conditions. The figures of Document No. 1262 were not a finished estimate and undoubtedly contain errors. There is seldom but one kind of error in figures of this kind, and that is an underestimate. To add to this unstable basis a round percentage (supposed to indicate the average increased cost of labor and materials) is merely to bring about an accumulation of error. It would be surprising if the cost of the dam should be even moderately in excess of figures made in this way.

In effect the administration began and is prosecuting without a suitable estimate a $50,000,000 hydroelectric power project.

The administration has expended or is committed for a total of $7,000,000 upon which there is a $4,500,000 salvage as we estimate it. Even if it were granted that a sufficiently useful purpose was to be secured from the construction of the Wilson Dam and power plant it would, nevertheless, seem proper to us that further construction should be held in abeyance until such time as, first, a complete study of the situation has been made; second, an estimate has been prepared; third, the Congress has had an opportunity of determining in its judgment whether the work shall proceed; fourth, Congress shall have made the necessary additional appropriation.

Otherwise it may well prove that within a few months, when the work has exhausted the full amount of $13,000,000 now allocated to it by the Secretary of War, that the Congress will not consent to making the additional necessary appropriation of substantially $37,000,000. In this connection it is to be borne in mind that, while complete stoppage of the work at this time would, according to our rough estimate, involve the Government in a loss of not over $2,500,000, the expenditures to be made from this time forth of the additional $6,000,000 are such as will be practically all wasted should the work be closed down when the $13,000,000 is exhausted, thus making the net loss in such case substantially $8,000,000.

Attached hereto is a tabulation of the figures from which the statements of costs herein have been taken.

May we ask that this letter and tabulation be printed in the record of the hearings.

Very truly, yours,

FRANK S. WASHBURN.

Analysis of Wilson Dam estimate contained in letter to Secretary of War, Apr. 17, 1920, from Maj. Gen. Lansing H. Beach, Chief of Engineers.

[Hearing Senate Committee on Agriculture, p. 352, S. 3390. Figures as per Document No. 1262, 1915–16

General engineering and office expenses	$2, 275, 000
Camps, general plant, and road connections	2, 212, 000
Dam No. 2	4, 127, 000
Lock No. 2	1, 064, 000
Substructure of power house and tail race	2, 000, 000
Flowage damages	350, 000
Road changes	30, 000
Clearing	76, 000
Head gates *	135, 000
Racks *	68, 000
Cranes *	50, 000
Generating equipment *	4, 200, 000
Cables and wiring *	150, 000
Total	16, 737. 000+75 per cent=$29, 290, 000

Power-house superstructure *	$524,000		
Outdoor substation *	3,360,000		
Stop logs*	49,000		
Engineering on equipment	427,000		
Administration chargeable to equipment	427,000		
Contingencies on equipment	1,280,000		
Total exclusive of interest	22,804,000	+75 per cent=	$39,908,000
Interest during construction	[1] 1,875,000		3,280,000
Total	24,679,000	+75 per cent=	43,188,000

5 per cent on * items=5 per cent on $8,536,000=$426,800.
5 per cent of * items=5 per cent on $8,536,000=$426,800.
15 per cent on * items=15 per cent on $8,536,000=$1,280,400.

The **Chairman**. The committee will now stand adjourned subject to call.

(Thereupon, at 1.35 o'clock p. m., the committee adjourned to meet at the call of the chairman.)

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[1] Assumed part of a total interest account of $6,935,800 in Document No. 1262.

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